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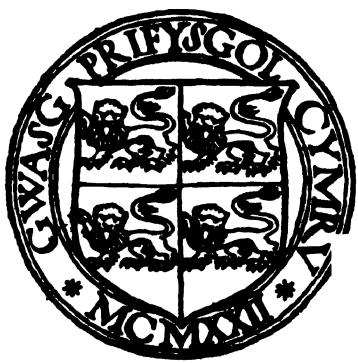

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DOES THE HIGHER FARMING PAY?

A STUDY IN DEPRESSION AND FARMING STANDARDS.

By Professor A. W. Ashby, M.A.,
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In every period of depression in agriculture suggestions are made that the standard of farming or of output should be reduced in order that profits may be maintained; and on various occasions since 1921 the advantages, if not the necessity, of low farming have been proclaimed, sometimes with considerable dogmatic emphasis. But no dogmatism is justified; and even a statement of general principle may involve very considerable risks of misleading individuals or even whole groups of farmers.

In so far as depression in the markets is due to over-production relative to the effective demand it will be true that maintenance of profits of the whole of the producers concerned will depend on reducing production. It is generally assumed that reduction will take the form of a decrease in the number of producers, the weaker or less efficient being pressed out of the market. But any such reduction may also be obtained through a reduction in the area devoted to production, or by lowering the standard of output over the existing area, each in proportion to the degree of over-production, or the reduction might be obtained by a greater than proportionate reduction in area while raising the standard of output on this reduced area. There is no absolute necessity that the number of producers should be reduced. We postulate such reduction as the result of competition amongst sellers on the basis of efficiency or advantage in production and of varying costs or producers' prices at which the products may be sold. There is, however, no special sanctity about competition, and foresight and organization may conceivably take its place. There are, indeed, times of general economic depression when the pressing out of a number of producers may be socially disastrous, however much this may be desirable from the point of view of " the economic health and vigour " of the industry.

According to the circumstances of the production of each product any of these methods may be effective in reducing supply to the quantity for which there is effective demand.

With various groups of producers competing for the effective demand in the markets in a period of depression each

group, national or local, may pursue its own interests in adapting production policies to existing conditions. Limitation of acreage (or numbers of livestock) or reduction in standard of output ought to be equally spread over the whole of the suppliers if each group is to retain its proportionate interest in the market. But it may and does happen that one group may be able to lower its costs by either increasing acreage (or numbers of stock) or by raising the standard of output, and thus maintain its profits. In the event of the pursuit of this method of meeting depression by one group the pressure on other competing groups will be increased. Thus there may be a scramble for markets, and in the circumstances of the British markets for many products this scramble may and probably will be of international character. The group which can lower its costs most quickly and to the greatest extent while maintaining or increasing its production will secure its position in the markets not only at the moment but more or less for the future.

This process of competition is more usually seen as the competiton of individuals who will compete with each other in the improvement of technical methods, equipment and productive organization, in order to lower costs and thus retain their individual positions in the market. The more efficient may increase the amounts of their individual products, the least efficient will be driven from this branch of production and from the markets. Where there is an international market for a commodity, like wheat, butter, or meat, for instance, the common assumption is that individuals in all producing areas will be competiting with individuals in their own countries or areas and with individuals in other countries, and that in any and every country the more efficient will remain in the industry and the less efficient will be pressed out. This, however, is not entirely the position. States are interested in the maintenance of the position of their producing and selling groups and various economic policies may be implemented for the support of those groups. The system by which. in effect, the export of German wheat has been subsidised is of that character of State support of a group of producers under intensive competition. The "Paterson Plan" by which an effective subsidy is paid on the export of butter from Australia—a matter of some importance to Welsh butter producers—is of the same character.

There are other forms of State assistance which make unequal conditions of competition. Research, education, demonstration at the expense of the general tax-payer, if effective in practical ways, may for a time give one group of producers—

or a large number of individuals in that group—an advantage over another group. The general effect of all such activities is that of making competition more intensive for the unassisted or unprotected producers. States move to protect national interests as well as the interests of individuals. The effects of measures designed to protect or assist may be such as put their nationals on a solid foundation for future operations, or they may be such as merely reduce the intensity of competition felt by the national group to a point at which the majority of producers can remain in the market and slowly adapt themselves to a new set of conditions and costs of production. In either case the national group maintains production, and meets demand, to a greater extent than it could do without assistance. The retention of the selling position on the market is itself of value to the group which will continue to require the market. Thus in a period of effective over-production, relative to the demand, the position of groups as well as of individuals has to be considered.

In recent years there have been some suggestions of "group" or "area" reductions in production of various agricultural products, and even some suggestions of international arrangements amongst producing groups to secure such reduction. One obstacle to the pursuit of any definite policy of this character is the recognition by States of varying interests in respect of the increase or decrease in production of a commodity in their respective areas. During every major depression the geographical distribution of production of the commodity of which the price is depressed is changed to some extent. Some countries which have facilities for adapting themselves most quickly to existing conditions may hope to increase their share of production and in this case others must lose unless there is eventual expansion of total demand.

A method of temporary alleviation of conditions may be found in the retarding of selling and the storage of products. During recent years this method has been applied by or for agriculturists, as by the Federal Farm Board of U.S.A., or the Canadian Grain Pools. It has been applied to some extent by individual producers in respect of the wool clip. This method is also applied by traders in agricultural produce, at least for short periods, as, for instance, in the greater amounts and the longer periods of storage of such products as eggs, butter, and meat at times of heavy supplies and low prices. There is no essential difference between the " holding back " of supplies by producers or on their behalf and " storage " by traders, but there is some difference in method. The group activity of

producers is a greater innovation than the (individual) activities of traders and as such is more suspect. The question whether such storage and temporary limitation of current market supplies is better undertaken by producers or by traders need not be discussed at the moment.

No such activities as the regulation or reduction of acreage planted, or the regulation of retarding of supplies entering markets, can be expected to stop a revolution in equipment and technical methods such as is occurring in grain production, or even the minor revolution in butter production. Such activities might retard changes or mitigate their effects for a period of time. But in view of the economic dislocation and the human trouble caused by such changes activities of States or of groups of producers to retard them or to regulate their effects may be economically justifiable, so long as the activities themselves improve the existing conditions without creating other conditions of less advantage.

When neither States nor organised groups of producers take action to regulate the conditions which lead to over-production or depression of prices, or to mitigate the effects of these, the individual producer is left to his own devices. The circumstances in which individuals pursue production show very wide variations. The rents or prices of farms in relation to capacity to produce a given product vary considerably, the types and quality of equipment vary from farm to farm, there is varying accessibility of capital for new or improved equipment or change in organisation, and producers themselves vary in their efficiency as producers. Moreover, the existing productive organisation under the control of each producer may vary in its position as regards the " cost schedule " to which it is already working. One may be farming to a high standard, with a high standard of production per unit of land, with relatively high costs—may possibly be working in the region of increasing costs (or diminishing returns) in the cost schedule. Another may be working at the optimum point in the cost schedule, producing at the lowest unit cost possible with the existing organisation.[1] Whilst a third may be farming on a low standard, with a low standard of output, and be within the region of diminishing cost (increasing return) on his cost schedule. These positions are of great importance. In the first case a lower standard of farming and reduced output is indicated, for costs per unit would

[1] There are some cases in which the optimum total profit standard of output, and the standard which gives lowest cost and the optimum margin between cost and profit, are not the same. Farmers may, and sometimes do, aim at the optimum total profit and not at the optimum profit per unit.

thereby be reduced. In the second case no change is indicated, while in the third case a higher standard of farming and of output is indicated for the reduction of unit costs. Without knowledge of the individual farm, there could scarcely be any reliable judgment of the kind of change required.

These considerations have reference to the type and scope of change in production policy with the existing farm enterprise at its current size. But a change in the size of the enterprise may itself make changes in production policy. Thus an increase in size of enterprise may be more easily possible for the man with the higher standard of production, and in spreading his facilities (capital, etc.) over a greater area he may both reduce costs and maintain or even increase total production. The producer with low standard of production might reduce the area over which he uses his capital, etc., and thus reduce costs, possibly without reducing total production. These possibilities depend upon the character of the changes in the technique and equipment which the particular enterprise is undergoing. At the moment, the changes in both cereal production and in dairying, but more particularly in the former case, are towards larger scale enterprise. Under such circumstances the producer who can extend his enterprise, and equip accordingly, will tend to have the greater opportunities of making changes which will be effective in enabling him to meet the circumstances of a depressed market.

This postulates competition between each producer, and the consideration of policy for each according to his circumstances. But it does not postulate that in the case of an " international market product " there will be equal political and social conditions in which the competition will be worked out, for it recognises that States will play varying parts in the support or assistance of their competing groups. These, together with varying natural and economic conditions which offer varying degrees of advantages as regards size of enterprises, use of machinery, or other conditions affecting costs, will lead to unequal conditions of competition both for national or area groups and for individuals within those groups. Nor should it be considered that no group interest remains, or that no principle will have a general application to the circumstances of a group when the production policy for each farm is determined according to its individual circumstances and competition is essentially of an individual character. Some group interests still remain, and in particular some demand preferences, or even specific demands, may be of value to groups of producers selling in an essentially international market. General conditions or circumstances

prevailing over the area and in the general economic environment in which any national or local group of producers work may also give rise to a general principle or principles applicable to the production policies of individuals within the group.

The position in Wales.

Welsh farming is predominantly of a pastoral character, and some 95 per cent. of the production of the Principality as a whole consists of livestock and their products. Nevertheless the general systems are far from the character of a merely pastoral production. Most of the products of the arable, some 24 per cent. of the total cultivated land, are consumed by livestock, and expenditure on purchased feeding stuffs amounts to about 25s. an acre against about 23s. an acre for rent of farms.[2]

The contribution of labour and purchased materials to production is far greater than that of land, at any rate in money value, and the apparently pastoral is essentially a commercial system of producing livestock and their products.

In the examination of the financial results of some Welsh farms for the year 1929 it became evident that there was some degree of association between standard of output and profits, and it appeared desirable to discover whether there was any principle which might indicate a possible production policy for the Principality as a whole, or whether there were indications of the lines of investigation which might lead to the discovery of such a principle.

The general position as regards prices in the year concerned is briefly indicated below.

Index of prices of farm produce.
(1911-13 = 100).

	1924.	*1929.*	*1930.*
All commodities ...	161	144	134
Milk ...	170	169	162
Cheese ...	162	152	127
Butter ...	164	158	132
Fat cattle ...	153	133	132
Fat sheep ...	187	157	159
Wool ...	192	126	100
Fat pigs—			
Porkers ...	139	165	165
Baconers ...	133	160	154
Eggs ...	168	159	137

[2] See " Farm and Market ", Vol. I, No. 2. Expenditure on feeding stuffs on farms dealt with below was £1 1s. 4d. per adjusted acre and 16s. 2d. per simple acre, while rent was 18s. 4d. per adjusted and 14s. per simple acre.

Although prices of livestock and their products have not fallen so rapidly as prices of crops, some of these prices suffered a fairly heavy fall from those previously ruling.

Thirty-nine farms are dealt with, and the general particulars are as follows :—

	Total.		*Per farm.*	
	Simple.	*Adjusted.*	*Simple.*	*Adjusted.*
Grass and crops ...	3,522	3,522	90	90
Rough grazings ...	1,674	418	43	11
Total ...	5,196	3,940	133	101

Capital	£34,100
Per farm	£875
Capital per acre (simple)	£6 11 0
(adjusted)	£8 13 4
Rent per acre (simple)	14 0
(adjusted)	18 4
Rent per farm (adjusted)	£92 8 4
Persons engaged per 100 acres—	
(simple)	2.5
(adjusted)	3.3

The use of two figures for land *i.e*, " simple " and " adjusted " acres, represents an effort to reduce rough grazings to a proportionate figure relative to the quality of other land, and as may be seen the divisor used is four. The " simple " area represents total area including rough grazings; and the adjusted area represents the cultivated area, plus one-fourth of rough grazing area. Unless otherwise stated all acres are " adjusted acres."

The type of farming varied from farm to farm, but with two exceptions all may be fairly described as mixed farms. Without exception the sales are almost wholly of livestock and their products.

The figure for capital represents all livestock and equipment, crops growing and stored, and other farm stores, but does not include tenant-right items of unexhausted residues. "Profits" are gross profits, for they include interest on capital and the earnings of the farmer (and generally of a wife) as worker and as manager, but all earnings (or wages due) of other family labour have been included as expenses. Profits in this sense are equal to gross income, and this is used below in two forms (*a*) " profits as per cent. of capital," and (*b*) " profits " or " income " per acre. But this gross profit or income is also

divided into (*a*) estimated earnings of labour of farmer and his wife according to time given to manual work, and (*b*) net profit (namely gross profit less estimated earnings of labour) and the net profit is quoted as per acre.

The output is stated in two forms (*a*) sales, namely total sales off farms, (*b*) gross output, which represents (1) closing valuation plus sales *minus* (2) opening valuation plus expenditure on live-stock. The gross output represents the production properly attributable to the farm during the year.

When the statistical method of correlation is applied to the data from the accounts of these farms some exceedingly interesting results are obtained.

The comparison of income in the forms mentioned above and the rate or standard of production as measured either by output or sales shows fairly close association. Between sales per acre and gross income as percentage on capital there is fairly close association, but there is a closer association between output per acre and gross income. There are much the same degrees of association between net profit (or interest) per acre and sales or output per acre except that there is a more marked association between net profit and output than between net profit and sales.

Income and Output combinations.

		Coefficient of correlation.	*Probable error.*
		(r =)	(±)
A. (1) Gross income as per cent. Capital.	B. Sales per acre.	+ 0.591	0.070
A. (2) Gross income as per cent. of Capital.	C. Gross output per acre.	+ 0.616	0.063
A. (1). (21) Gross income per acre.	C. Gross output per acre.	+ 0.875	0.025
A. (1). (23) Gross income per acre.	B. Sales per acre.	+ 0.663	0.06
A. (2). (11) Net profit per acre.	B. Sales per acre.	+ 0.596	0.069
A. (2). (12) Net profit per acre.	C. Gross output per acre.	+ 0.668	0.06

There is a very close association between gross income per acre (omitting the variations in capital per acre) and gross ouput, and much closer than that between income per acre and sales per acre. (Attention is particularly directed to correlation No. 21 in the combinations above). Output is a better measure of

production than sales, for the amount of the latter is so much subject to the influence of purchases and sales in short period production or trading transactions, and therefore greater importance is attached to the degree of association between income and output than between income and sales.

From these measures of the association between income and output it may be said that the higher outputs tend to be associated with higher earnings as income stated as percentage of capital, and with the higher incomes stated as income per acre, and particularly the latter. Indeed, it may be said on the basis of these measures that if these farmers are concerned with the greatest income per acre and therefore with the greatest income from their farms irrespective of capital and of the rate of earnings of capital, those with the higher outputs tend to secure the best results.[3]

The results suggest that a number of the farmers are farming in the region of diminishing costs with possibilities of increasing output. It is possible that some may be producing in the region of increasing costs or diminishing returns, but that they are producing up to the standard which yields the optimum income. A comparison of the correlation coefficients No. 2 and No. 21 in the Table above suggests that this may be the case. On the other hand, the examination of a number of individual accounts rather suggests that production might be increased with expectation of increased profits or income so long as sound technical and business methods were followed.

As farmers cannot proceed entirely on crude measures of income the degree of association between capital and income has

Income and Capital.

		Coefficient of correlation.	*Probable error.*
		(r =)	(±)
A. (1). (10) Income per acre.	E. Capital per acre.	+ 0.644	0.068
A. (9) Income as per cent. of Capital.	E. Capital per acre.	+ 0.549	0.075

been ascertained and the coefficients of correlation are stated above. There is fairly close association between income per acre

[3] This statement should be considered with reference to the note, p. 8. If land is relatively scarce and capital plentiful, a farmer may seek the highest profit on the farm in hand, but when land is available and capital scarce or dear he may seek more land, spread his capital over a greater area, lowering standard of production, in seeking the optimum return on capital.

and capital per acre, but a lower degree of association between income measured as percentage of capital and capital per acre.

There are necessarily many complexities in a study of income in relation to output and some of these are connected with variations in quality (fertility and economic productivity) of land, and the rents of farms in relation to these variations, to capital and other factors. For this reason a fairly elaborate study of the association of rents with some of the factors has been made.

Rent combinations.

		Coefficient of correlation.	*Probable error.*
		(r =)	(±)
D. (4) Rent per acre.	C. Gross output per acre.	+ 0.958	0.009
D. (4a) Rent per acre.	B. Sales per acre.	+ 0.868	0.026
D. (7) Rent per adjusted acre.	E. Capital per adjusted acre.	+ 0.753	0.043
D. (1). (16) Rent per simple acre.	E. (1). Capital per simple acre.	+ 0.900	0.020
D. (8) Rent per acre.	F. Labour per 100 acres.	+ 0.504	0.080
D. (22) Rent per acre.	A. (1). Gross income per acre.	+ 0.678	0.058

As might perhaps be expected there is very close association between the standard of production whether measured by sales or by output and the rent per acre. If the variations in rents indicate fairly accurately the variations in the fertility and economic productivity of land, then it might be said that the higher outputs are associated with the more productive land and *vice versa*. This is probably the tendency although it is not quite certain.[4] There are certainly variations from farm to farm, and it is important to remember that fairly high rents themselves induce higher output in certain cases, and that certain farms of fairly high fertility and economic capacity let at relatively low rents tend to produce at a low standard because of absence of economic pressure. Whether rents fully represent variations in fertility and economic productivity of land, or whether the higher rents themselves tend to induce higher output, the close association between rent and output is clear.

[4] See Howell and George. "Rent and Stock-carrying Capacity of Farms". This *Journal*, Vol. VI, 1930.

The tendency for the higher capitalisation and the higher rentals to be closely associated on these farms suggests that for this group the higher rentals are associated with the land of higher economic productivity. The degree of association of variations in rent with variations in capitalisation are stated per " simple " and per " adjusted " acre as defined above (p. 11). In each case there is a close association of the higher capitalisation with the higher rentals.

The degree of association between the amount of labour and the rent of land, or between the amount of labour and the quality of land if rent is taken as indicative of quality, is not so close as might have been expected. But it must be remembered that capital equipment in some forms is a substitute for manual labour.

Finally, the degree of association between rent and income per acre is fairly close.

Then there is very close association between output and capital per acre, but a fairly low degree of association between output and amount of labour used. The degree of association between output and labour is slightly higher and more certain than the association between rent and labour.

Output, capital, and labour.

		Coefficient of correlation.	*Probable error.*
		(r =)	(±)
C. (5) Gross output per acre.	E. Capital per acre.	+ 0.834	0.033
C. (6) Gross output per acre.	F. Labour per 100 acres.	+ 0.517	0.079

In general higher rentals and the high capitalisation are associated with the higher outputs and these are associated with the higher profits or earnings. There is no indication that these farmers would be well advised to reduce their output or to lower their standards of farming in a period of relative depression. On the contrary the indications are that in general some increases in production would bring higher earnings, certainly higher earnings per acre and for the whole farm, and in most cases higher gross profits as per cent. of capital.

But policies for improving methods and increasing production cannot be considered in the abstract, they have to be considered in relation to each farm, and to each farmer in his

economic circumstances. Some increase in capital owned or used would be antecedent to increase in production and the positions of farmers vary in respect of possibilities of obtaining capital. It is probable that capital is the limiting factor in a number of individual cases. The enterprises in which increase in production should be sought will vary from farm to farm, but almost universally in Wales the fundamental technical and business bases of improved and increased production are :—

(1) Grass-land improvement
(2) The search for the most economical concentrate rations for use with home-grown feeds
(3) The selection of the best type of livestock (of whatever kind) for the productive objects aimed at
(4) The adjustment of type of final product to market demand
(5) Efficient marketing organisation.

As regard (2) above it might be suggested that possibilities of changes in crop-husbandry towards production of more of the foodstuffs with the higher protein content might be considered and that trials might be made along lines which show any promise of practical and economical results.

Opportunities of increasing production at lower costs exist and although they are not without limit they are worth pursuing. In specific enterprises and cases the opportunities are obvious. Where butter-making has been pursued with calf-rearing on the skim-milk feeding system the butter output per cow under fairly equal conditions from farm to farm varies between 80 and 150 lb. per cow per annum and in extreme cases from 60 to 215 lbs. per cow per annum. There is evidently opportunity for grading up at the lower points even though the most efficient producers may temporarily have reached the optimum. Competitors' selling pressure on the market has created great difficulties for this type of enterprise in Wales during recent years, but especially in 1926-27 and in 1930. This selling pressure has been due largely to the improvement and increase in production by competitors. In New Zealand, for instance, the increase in butter-fat production per cow between 1901 and 1926 is estimated at 71 lb, namely 1901-2, 127 lb. and 1926-27, 198 lb. per annum, while the increase in value of butter-fat per cow at standard values is said to have been from £7 18s. 10d. to £12 8s. 0d. per cow. Very considerable increases in butter-fat per cow have been obtained in Denmark also.

In the case of milk production for the wholesale trade there are also wide variations in the yield per cow and in the cash

value of milk per cow consequent on difference in total yield, in seasonal production and in differences in price per gallon consequent upon seasonal production. Although there are great differences in costs under different systems of production there also considerable differences in costs and profits under similar systems. There is considerable scope for reduction in costs by selective breeding for increase in yield and by close scrutiny of feeding and yields on individual farms.

In the case of egg production, the yield per hen under general farm possibilities which are quite comparable varies between 50 and 120 eggs per annum, and at the higher ranges 150 to 180 eggs per annum. But 120 ought to be generally possible and 100 should be regarded as a minimum. Yet there are many flocks producing between 70 and 90 eggs per bird.

Similarly sheep enterprises mainly producing store lambs under fairly similar conditions show outputs per breeding ewe varying between 15s. and 30s. per annum, while other types of lamb raising enterprises show variations in output per ewe between 30s. and £3 15s 0d. per annum. Variations in the sheep enterprises do not admit of quite such close comparison as those in the other enterprises mentioned, nevertheless there are wide variations in the productivity of flocks kept for similar purposes under fairly similar conditions. Although sheep enterprises in Wales have given fairly satisfactory results in recent years, there has recently been some danger to the markets and considerable selling pressure from exporting competitors. In New Zealand, again, the increase in production per sheep 1901 to 1927 is estimated at about 30 per cent. From some study by surveys and accounts it may be suggested that the main factors in the improvement of this enterprise in Wales are probably lamb-yield, and condition of lambs at time of marketing, and the conditions to be watched are those which determine yield of lambs—condition of ewe flock and breeding conditions, disease, and conditions of feeding; and the general conditions of feeding and attention which determine conditions of lambs at time of marketing. In some cases the more careful selection of type—breed or cross—for the market purposes in view is of great importance.

These are some of the types of semi-technical, semi-economic problems which present themselves in relation to improvement and increase in production in Welsh agriculture.

If competition is to determine who is to retain markets and to remain in farming, the basis of that competition will be the efficiency of individuals and of groups of producers with whatever support and assistance they can obtain from the political

and fiscal systems of the States under which they operate. Competition will not be entirely of an individual nor entirely of a group character. But as regards presentation of the produce to the markets it may be largely of a group character. Even where competition may appear to be largely of individual character as regards production it will also have group characteristics, even though there may be little formal group action, in marketing and the securing of markets. Where farmers of any area have opportunities of increasing production at diminishing cost, and where their produce is such as to induce and stimulate demand there are specific opportunities for them irrespective of general market conditions. In the absence of concerted effort to regulate total production according to effective demand each area or national group, and each producer within that group, must study possibilities and pursue such as can be found. Some individuals, and in effect some groups, will lose a part or the whole of their share of the markets in this competitive process, and those groups which delay adaptive and improving processes for the longer periods will suffer the greater losses.

There are, of course, temporary possibilities of meeting competition and economic depression merely by what have been called the " belt-tightening " methods—namely, the sacrifice of standards of remuneration and of living, and working and using capital for low rates of remuneration. These are methods for those individuals and groups whose circumstances are such as to preclude possibilities of competition or any other basis; such producers can scarcely hope to retain permanent positions on the markets or in the industry. But there are circumstances in which the temporary reduction of personal expenditure may provide capital for the adaptive processes necessary for effective competition. These circumstances exist on some Welsh farms at the present time. So far as can be seen there are opportunities of profitable increase in production for many producers if they can obtain the capital and the technical information with which to pursue them.

SOME FACTORS OF EFFICIENCY IN MILK PRODUCTION.

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There has been much study of milk yield and of rationing and some study of selection and breeding with a view to showing the foundations of efficiency in milk production. But there has been relatively little study of the financial factors in herd management. It is because of this lack of information that an investigation of the cost of producing milk in the liquid milk areas of Wales has been conducted since 1925. But the results given in this article only cover three years of the study and during this period returns have been obtained for eighty-eight cases, each case representing one herd for one year.

TABLE I.

Average cost of producing milk (three years' results).

		Total.	*Average.*
Number of cases	88		
Number of cows in herds ...		1,848	21
Number of cows in milk ...		1,535	17.4
Number of cows dry		313	3.6
Total milk yield ...	1,109,854 gallons.		
Average per cow in herd		600 ,,	
Average per cow in milk		722 ,,	

	Cost per Cow. £ s. d.	*Cost per Gallon. Pence.*	*% to total %*
Home Grown Foods	6 14 7	2.69	25.14
Purchased Foods	6 2 3	2.44	22.84
Pasturage...	3 19 7	1.59	14.87
Labour	6 3 10	2.57	23.14
Depreciation on Cows	2 8 0	0.96	8.97
Depreciation on Equipment	0 5 7	0.11	1.04
Keep of Bull or Cost of Service	0 12 11	0.26	2.44
Miscellaneous	0 8 4	0.17	1.56
Gross Cost	26 15 1	10.79	100.00
Credits	2 11 2	1.03	9.58
Net Cost	24 3 11	9.76	90.42

The average size of the herds costed has been about twenty-one cows, the largest herd consisting of sixty-five cows and the smallest herd of six. The average size of these herds is greater than the average size of herds in Wales, which is about ten cows.

TABLE II.

Comparison of costs—(mean of three years' results).

	Herds with Highest and Lowest Cost per Cow.				*Herds with Highest and Lowest Yields.*			
	Highest Cost.		*Lowest Cost.*		*Highest Yield.*		*Lowest Yield.*	
No. of Cows in Herd	14.4		24.0		7.4		32.25	
No. of Cows in Milk	13.5		18.25		5.8		26.50	
No. of Cows Dry	0.9		5.75		1.6		5.75	
Total Milk Yield	10,672 gals.		13,616 gals.		6,416 gals.		13,946 gals.	
Yield per Cow in Herd...	740 ,,		567 ,,		867 ,,		432 ,,	
	Cost per Cow. £ s. d.	*Cost per Gallon.* *Pence.*	*Cost per Cow.* £ s. d.	*Cost per Gallon.* *Pence.*	*Cost per Cow.* £ s. d.	*Cost per Gallon.* *Pence.*	*Cost per Cow.* £ s. d.	*Cost per Gallon.* *Pence.*
Home Grown Foods	8 19 6	2.91	3 2 0	1.31	4 8 1	1.22	5 2 2	2.83
Purchased Foods	14 18 8	4.84	2 15 8	1.18	5 9 2	1.51	3 18 4	2.17
Pasturage	2 7 2	0.76	3 19 10	1.69	3 6 9	0.93	6 1 6	3.37
Labour	10 17 8	3.53	4 18 11	2.09	4 1 6	1.13	7 16 10	4.36
Depreciation on Cows	5 5 3	1.73	1 0 10	0.44	0 16 6	0.23	0 4 1	0.11
Depreciation on Equipment	0 17 5	0.28	0 0 8	0.01	0 8 10	0.12	0 5 4	0.15
Keep of Bull and Cost of Service ...	1 15 0	0.57	0 8 3	0.17	0 2 6	0.04	0 9 5	0.26
Miscellaneous	2 5 1	0.73	—	—	0 1 9	0.02	0 0 9	0.02
Gross Cost	47 5 9	15.35	16 6 2	6.89	18 15 1	5.20	23 18 5	13.27
Credits	1 12 4	0.54	2 7 0	0.99	2 15 1	0.76	1 16 10	1.02
Net Cost	45 13 5	14.81	13 19 2	5.90	16 0 0	4.44	22 1 7	12.25

But the majority of Welsh herds are used for stock raising and for butter making. Milk selling farms carry the larger herds.

The average costs over all the herds costed during the three years are given in Table I. These average figures are weighted by size of herds.

The cost of food, including grazing, represents about 68 per cent. of the total gross cost, labour about 23 per cent., depreciation on the herd nearly 9 per cent., and other items of cost about 5 per cent. These proportions vary to some extent from farm to farm, but the average proportions are practically constant from year to year.

The variations in yield of milk are given below. The figure " per cow in herd " represents the total yield of milk divided by the number of cows reduced to cows on the farm for a whole year : that is, the yield for " one cow one year in herd ". The " yield per cow in milk " represents the total yield divided by the number of cows reduced to " one cow in milk for one year " : the reduction in this case being the allowance for the period which the cows spend in dry condition.

	Per cow in herd.	*Per cow in milk.*
	gallons.	*gallons.*
Average milk yield (three years) ...	600	722
Herd with lowest yield (three years) ...	432	526
Herd with highest yield (three years) ...	867	1,106

For the group of herds in each individual year there is scarcely any variation in the average yield of milk and no such variation as would distinguish one year from another.

The highest and lowest costs per cow in herd show very wide variations (Table II). The herd with the highest cost is kept in a mountainous region for supplying milk to a mining town. The high cost is due to a long winter feeding period with heavy purchases of concentrates and to frequent purchase and resale of cows leading to heavy depreciation. The herd with the lowest cost is situated in an open pasturage area, with a relatively short winter feeding period. The herd is all home-bred, with relatively little depreciation.

When costs are measured against the highest and lowest yields, two herds are found in a fairly open grazing area. The highest yield is found on a very small pasture holding run by a man who is essentially a good judge of cows and a careful and efficient manager. The lowest yield is found in a large herd. The cows have not been bred or very carefully selected for milk production and feeding has not been studied. On the whole this herd is managed in haphazard ways.

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The records of milk production obtained for the eighty-eight cases show that great variations in costs occur from farm to farm and among some of the factors which account for these variations may be mentioned :—

(1) The system of herd management.
(2) The yield of milk.
(3) The arrangement of rations.
(4) Purchase or production of foods.
(5) General management, including labour, organisation and control of equipment.

Management of the herd.

Choice of bull.

One important item in the management of the herd is the management of the bull with a view to securing good service at an economical cost. To the owner of an established dairy herd, the selection of a young bull is one of the most practical points. As far as the improvement of the herd is concerned, this can only be done by breeding and the test of the improvement is that the home-bred heifers should be better animals and better milkers than their dams, and the chief agent in this improvement must therefore be the bull. Apart from the selection of a bull being based on external appearances, and whether the bull conforms to the points of a favoured breed, it is also very important to know something about the dairy characteristics of the bull's dam and if possible his grand dams—that is, whether they were cows of good type, healthy and with well developed, shapely udders and teats. Another point that should be considered is the milk record of the dam and grand dam. These should be carefully studied, not forgetting the fact that an average yield of 700 gallons per annum is a better indication of the constitution and milking properties of the cows than one year's yield of 1,000 gallons. There is no doubt that " the bull is half the herd " and few dairy farmers have such herds that they can afford to use a second or third-rate bull if they intend to raise heifers.

Methods of maintenance of herds.

One of the problems of the dairy farmer is how to maintain his herd in the most economical way. Some dairy farmers maintain their herds by the introduction of home-bred stock, others partly with home-bred stock and partly by purchase, while others maintain their herds entirely by purchase. Part of the effect of these systems on the cost of producing milk will be shown in the amount of appreciation or depreciation on the herd. While

a large number of dairy farmers are able to breed and rear cows for the maintenance of the herd, there are others that have not the facilities for rearing stock. Possibly it may not be true economy under all conditions and at all times to breed and rear cows for the maintenance of the herd. So much depends on the objective in milk production. If a farmer is bound by contract to provide a uniform supply of milk throughout the year he may find it impossible to do so without purchasing some of his cows. Again, the farmer who has not the facilities for rearing stock may find it less costly to rely on purchased cows for maintaining the herd than to find ways and means of breeding his own stock.

On farms consisting of land all of good quality for milking purposes it may and probably will pay better to buy cows than to rear heifers. Rearing heifers on high quality land at high rental is likely to prove uneconomical. But when a farm contains some second-rate land, not specially adapted to grazing by the dairy herd, the rearing of heifers is likely to be economical and profitable. Where there is a fair amount of arable land and some straw is available for wintering, the raising of heifers for herd maintenance may also be economical.

In the purchase of cows the risk is not limited to the possibilities of milk yield, but is largely a matter of the health of the cows purchased and the risk of disease not only in the actual animals which may be purchased, but occasionally in the contamination of the herd.

"Turnover" of herd.

From the cost records of the eighty-eight cases obtained in Wales during the three years of study the figures at the beginning of years showed that 44 per cent. of the cows were home-bred and 56 per cent. were purchased. Out of the eighty-eight cases, thirteen consisted entirely of purchased cows and ten consisted of cows which had all been bred by the farmer; while the remaining cases consisted of some home-bred and some purchased cows. Of the cows and heifers added to the herds during the three years, 48 per cent. of them were home-bred and 52 per cent. were purchased, and of the total 2,898 cows passing through the herds, 45 per cent. were home-bred and 55 per cent. were purchased.

During the three years 455 cows were sold and fifty-six died. Incidentally it may be noted that the death-rate was about 8 per cent. per annum, and that more than 10 per cent. of renewals, apart from increases in herds, were necessitated by deaths. There is no information on which a comparison may be made

with other areas or other periods. This would indicate that cows are kept in the herd on these farms an average of three-and-a-half years. The cows sold realised a sum of £8,145 8s. 7d., or £17 18s. per cow, and 302 cows were bought for £6,999, or £23 3s. 6d. per cow. The estimated value of the 270 heifers transferred into the herd was £5,847, or £21 13s. per head. The average charge for depreciation on the cows for the whole period was £2 8s. per cow, or 0.96d. per gallon. The variations in the depreciation on cows from farm to farm were considerable and ranged from an appreciation of 4s. 7d. per cow per annum to a depreciation and resale loss of £8 5s. 4d. per cow per annum.

Depreciation on cows.

The herds consisting mainly of purchased cows showed a higher depreciation than those where the majority were home-bred. This is illustrated in Table III, where the herds have been divided into four groups and classified according to the percentage of home-bred cows in the herd.

TABLE III.

Percentage home-bred and depreciation per cow and per gallon.

% Home Bred.	*Average % Home Bred.*	*No. of Herds.*	*Depreciation per Cow.*	*Depreciation per Gallon.*
Group.	%	*No.*	£ s. d.	*Pence.*
Under 25%	5.3	25	3 6 1	1.28
25% to 50%	43.4	18	2 6 10	1.03
51% to 75%	61.6	18	2 0 8	0.83
76% to 100% ...	91.0	27	1 11 3	0.63

From the figures it will be seen that there was a depreciation of £3 6s. 1d. per cow and 1.28d. per gallon on those herds where less than 25 per cent. of the cows were home-bred and that there was a gradual reduction in the amount of depreciation per cow and per gallon as the percentage of home-bred cows in the herd increased.

When the herds are classified on the basis of the amount of depreciation per cow, the same general tendencies are found. The results obtained by this classification of cases indicate that a low depreciation per cow is associated with a high percentage of home-bred cows in the herd. Thus, for the group of farms where the depreciation on the herd is under £1 per cow, the average percentage of home-bred cows in the herd is a little over 69 per cent. For the same herds the average depreciation is

5s. 8d. per cow and 0.15d. per gallon. Taking the other extreme, where the group of farms fall into a class with depreciation of over £4 per cow, there is only an average of 25 per cent. home-bred cows in the herds and the average depreciation is £3 18s. 5d. per cow and 2.24d. per gallon.

The effect of the different methods of maintaining the herds on the amount of depreciation is further illustrated in Table IV. Here the herds have been divided into four groups, namely those consisting of all home-bred cows, those where all the herds consist of purchased cows, those having 60 per cent. and over home-bred cows and those having 60 per cent. and over purchased cows.

TABLE IV.

Depreciation on herd.

Group.	*No. of Cases.*	*Depreciation per Cow.*	*Depreciation per Gallon.*	*Credit of Calves per Cow.*
	No.	£ s. d.	*Pence.*	£ s. d.
100% Home Bred ...	10	1 11 0	0.61	2 3 2
100% Purchased ...	13	3 9 0	1.29	1 18 2
60% and over Home Bred	36	1 12 11	0.65	2 2 8
60% and over Purchased	31	3 3 10	1.22	1 18 0

Group.	*Credit of Calves per Gallon.*	*Yield per Cow in Herd.*	*Net Cost per Cow.*	*Net Cost per Gallon.*
	Pence.	*Gallons.*	£ s. d.	*Pence.*
100% Home Bred ...	0.83	608	21 5 1	8.39
100% Purchased ...	0.72	640	26 0 8	9.76
60% and over Home Bred	0.84	609	22 2 11	8.74
60% and over Purchased	0.73	625	25 9 6	9.78

The depreciatior per cow and per gallon is about twice as much on the herds consisting entirely of purchased cows as it is on the herds which are maintained by the introduction of home-bred cows. The same is true when a comparison is made of the herds of 60 per cent. and over purchased cows with those herds of 60 per cent. and over home-bred cows.

One of the credits made before determining the net cost of milk production is the value of the calves. If depreciation on the herd makes an important addition to the cost of production, credits due to the value of the calves may make a considerable

reduction. For each group the depreciation on the herds and the credits due to calves was as follows :—

Group.	*Depreciation per gallon.*	*Credits of calves per gallon.*
	Pence.	Pence.
100 per cent. home-bred ...	0.61	0.83
100 per cent. purchased ...	1.29	0.72
60 per cent. and over home-bred ...	0.65	0.84
60 per cent. and over purchased ...	1.22	0.73

For the groups consisting of all home-bred and those of 60 per cent. and over home-bred cows, the credit due to calves more than compensates for the loss on the herds. In the case of the other groups, even after making these deductions, there is still a loss on the cows.

When, however, the milk yield is considered, it will be seen by reference to Table IV that the average yield for the group consisting of all purchased cows is thirty-two gallons more per cow than for the group of all home-bred cows. Again in the case of the group for which 60 per cent. and over were purchased, the average milk yield is 16 gallons more per cow than for the group of 60 per cent. and over home-bred cows. On a comparison being made of the net cost per cow and per gallon of milk the herds which show the lower costs are those for the groups of all home-bred and 60 per cent. and over home-bred cows.

Cost of food.

Feed is the largest single item of cost in the production of milk and it is generally recognised that success in dairy farming is intimately bound up with efficient methods of feeding the herds. The relation of feed consumed to milk produced may therefore be taken as the most vital problem in milk production.

In the feeding and handling of dairy herds, there are many different items which enter into or affect the feeding programme. During the winter when the dairy herds are housed the cows are fed on a ration consisting of a variety of different home-grown and purchased foods, and the nature of the feeding will mainly depend on the kind and quantities of home-grown foods available. During the summer while they are on pasture they seldom receive anything in addition to grass.

The nutritive value of home-grown foods may vary considerably and their value as feed will depend on the soil on which they were grown, the manurial or other treatment of the soil, the weather conditions during the growing season and at time of harvesting, and the conditions under which they were stored.

TABLE V.

Home-grown and purchased foods fed per cow and per 100 gallons.

Number of Herds	26		32		30		88	
	Group 1.		*Group 2.*		*Group 3.*		*All Groups.*	
Food.	*Under 550 Gallons.*		*550 and under 650 Gallons.*		*Over 650 Gallons.*			
	Per Cow.	*Per 100 Gallons.*	*Per Cow.*	*Per 100 Gallons.*	*Per Cow.*	*Per 100 Gallons.*	*Per Cow.*	*Per 100 Gallons.*
	Cwt.	*Cwt.*	*Cwt.*	*Cwt.*	*Cw .*	*Cwt.*	*Cwt.*	*Cwt.*
Hay	27.00	5.54	22.44	3.77	27.58	3.88	25.38	4.22
Straw	5.03	1.03	4.74	0.79	3.78	.53	4.53	0.75
Roots	33.79	6.93	18.99	3.18	14.72	2.07	21.91	3.65
Other Green Foods	3.53	0.72	23.43	3.93	3.72	1.04	12.63	2.10
Total Bulk Food	69.35	14.22	69.60	11.67	49.80	7.52	64.45	10.72
Home Grown Corn	2.81	0 58	1.09	0.18	1.63	.22	1.76	0.29
Purchased Cakes	3.35	0.68	4.73	0.78	6.86	.96	5.01	0.83
Purchased Meals	4.94	1.01	5.97	1.01	9.64	1.35	6.83	1.14
Total Purchased Foods	8.29	1.69	10.70	1.79	16.50	2.31	11.84	1.97
Total Concentrates Home Grown and Purchased	11.10	2.27	11.79	1.97	18.13	2.53	13.60	2.26

Again, the nutritive value of purchased foods will depend upon the class of food stuffs bought and their suitability as feed to dairy cows. The quality and amount of grass which the cows obtain while on pasture is another important factor affecting the quantity of milk produced during the year. Unfortunately, no satisfactory measure is as yet available as to the amount of nutrients cows obtain from pasture.

In presenting Table V the general classes of both the home-grown and the purchased feed stuffs are given, but the details, *e.g.*, mangolds or swedes under " roots " and oats or barley under " home-grown corn " are not given. Thus there is made for the moment an assumption that the various foods in any specific class are of equal feeding value for the purposes of this comparison. While this may not be wholly true the variations in feeding value of feedstuffs composing any of these specific classes are not so great as those in the quantities fed. Pasturage is treated separately.

The quantity of foods used per cow and per 100 gallons is shown in Table V.

In general, it may be said that the low producers received more bulk foods than the higher producers. The average quantity of hay fed is slightly over 25 cwt. per cow. The group of herds producing 550 and under 650 gallons of milk is lowest in this respect and probably this is due to larger quantities of other green foods being fed. Taking roots and other green foods together, the quantity consumed per cow is 37.12 cwt. (Group 1), 42.42 cwt. (Group 2), 18.44 cwt. (Group 3), with a general average of 34½ cwts. per cow for all the groups. The use of straw declines as the groups increase in the quantity of milk produced. As regards concentrates (home-grown and purchased), the quantity consumed per cow is less for the lower yielding than for the high yielding group of herds, the figures being 11.10, 11.79, and 18.13 cwt. per cow.

The quantity of food fed per 100 gallons of milk produced for each group is as follows :—

	Group 1. Per 100 gallons.	*Group 2. Per 100 gallons.*	*Group 3. Per 100 gallons.*	*All Groups. Per 100 gallons.*
	cwt.	cwt.	cwt.	cwt.
Total bulk foods ...	14.22	11.67	7.52	10.72
Total concentrates (home-grown and purchased) ...	2.27	1.97	2.53	2.26

It is often assumed that the bulk foods in a dairy cow's ration largely provide for body maintenance and that the

TABLE VI.
Gross cost of home-grown and purchased foods per cow and per 100 gallons.

Number of Herds	26		32		30		88	
	Group 1.		*Group 2.*		*Group 3.*		*All Groups.*	
Food.	*Under 550 Gallons.*		*550 and under 650 Gallons.*		*Over 650 Gallons.*			
	Per Cow.	*Per 100 Gallons.*	*Per Cow.*	*Per 100 Gallons.*	*Per Cow.*	*Per 100 Gallons.*	*Per Cow.*	*Per 100 Gallons.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Hay	3 13 4	0 15 1	3 5 6	0 11 0	4 0 9	0 11 4	3 12 7	0 12 1
Straw	0 10 8	0 2 2	0 10 5	0 1 9	0 6 9	0 0 11	0 9 4	0 1 7
Roots	1 10 8	0 6 4	0 17 11	0 3 0	0 13 9	0 2 0	1 0 3	0 3 4
Other Green Foods	0 9 4	0 1 11	1 11 9	0 5 4	0 9 8	0 1 4	0 16 7	0 2 9
Total Bulk Food	6 4 0	1 5 6	6 5 7	1 1 1	5 10 11	0 15 7	5 18 9	0 19 9
Home Grown Corn	1 1 1	0 4 4	0 8 3	0 1 5	0 15 9	0 2 3	0 15 10	0 2 8
Purchased Cakes	1 16 5	0 7 6	2 13 10	0 9 0	3 11 11	0 10 2	2 14 6	0 9 1
Purchased Meals	2 9 7	0 10 3	3 2 1	0 10 4	4 11 6	0 12 11	3 7 9	0 11 3
Total Purchased Foods	4 6 0	0 17 9	5 15 11	0 19 4	8 3 5	1 3 1	6 2 3	1 0 4
Total Concentrates Home Grown and Purchased ...	5 7 1	1 2 1	6 4 2	1 0 9	8 19 2	1 5 4	6 18 1	1 3 0

concentrates fed are primarily for production. In general, the above figures bear out this assumption.

The gross cost of home-grown and purchased foods per cow and per 100 gallons is given in Table VI.

The average gross cost of bulk foods is £5 18s. 9d. per cow, and 19s. 9d. per 100 gallons and the average gross cost of concentrates (home-grown and purchased) is £6 18s. 1d. per cow and £1 8s. per 100 gallons. The gross cost of all foods is £12 16s. 10d. per cow and £2 2s. 9d. per 100 gallons. When the value of grazing is added, the average gross cost of the foods including grazing is £16 16s. 5d. per cow and £2 16s. per 100 gallons. (Table VII).

TABLE VII.

Total gross cost of home-grown foods, purchased foods, and grazing per cow, and per 100 gallons.

Number of Herds ...	26		32	
	Group 1.		*Group* 2.	
Food.	*Under* 550 *Gallons.*		550 *and under* 650 *Gallons.*	
	Per Cow.	*Per* 100. *Gallons.*	*Per Cow.*	*Per* 100 *Gallons.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Home Grown ...	7 5 1	1 9 9	6 13 11	1 2 5
Purchased	4 6 0	0 17 8	5 15 11	0 19 5
Grazing	4 10 3	0 18 6	3 15 1	0 12 7
All Foods and Grazing ...	16 1 4	3 5 11	16 4 11	2 14 5

Number of Herds ...	30		88	
	Group 3.		*All Groups.*	
Food.	*Over* 650 *Gallons.*			
	Per Cow.	*Per* 100 *Gallons.*	*Per Cow.*	*Per* 100 *Gallons.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Home Grown ...	6 6 8	0 17 10	6 14 7	1 2 5
Purchased	8 3 6	1 3 1	6 2 3	1 0 4
Grazing	3 15 6	0 10 8	3 19 7	0 13 3
All Foods and Grazing ...	18 5 8	2 11 7	16 16 5	2 16 0

From an examination of these figures it will be noticed that the gross cost of food (including grazing) per cow rises from the

lower to the higher yielding herds and that there is a decrease in the cost of food per 100 gallons of milk produced. The figures are summarised below :—

	Group 1.	*Group 2.*	*Group 3.*	*All Groups.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
All foods including grazing, per cow ...	16 1 4	16 4 11	18 5 8	16 16 5
All foods including grazing, per 100 gallons ..	3 5 11	2 14 5	2 11 7	2 16 0

From these gross costs, deductions must be made for the value of manurial residues. For this purpose deductions have been made at one-half of the theoretical standards (Hall and Voelcker's Table), because it is estimated that this figure more nearly represents residual values on these farms. If deductions are made at full theoretical value, differences in net cost will be greater than shown.

Apart from a reduction in the total costs the position of the groups as regards cost of food is the same as in Table VII, that is, the cost of food per 100 gallons falls as production increases, while the reverse is true of the cost per cow. A summary of the results is as follows :—

	Group 1.	*Group 2.*	*Group 3.*	*All Groups.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
All foods including grazing, per cow ...	15 11 10	15 13 7	17 9 10	16 4 6
All foods including grazing, per 100 gallons ...	3 4 0	2 12 6	2 9 4	2 14 0
Average yield per cow in herd (gallons) ...	487	596	709	600
Average yield per cow in milk (gallons) ...	596	714	843	722

Purchase or production of foods.

The question of the relative economy of purchase *versus* production of foodstuffs cannot be fully discussed because of the conditions under which the information was obtained, but some considerations are given below. No records of " costs " of producing feeds were obtained from the farms concerned. The estimated " costs " of production value of home-grown feeds was determined after consideration of the cost of the commodities on other farms, and in some cases after discussion of the cost or feeding value of the commodities with the owners of individual herds. Hence for home-grown foods the costs per

unit may be described as " conventional costs ". They varied to some extent from farm to farm, but the average unit costs were as follows :—

	Per ton.
	£ s. d.
Hay ...	2 17 3
Straw (mainly oat) ...	2 1 2
Roots ...	0 18 6
Other green foods ...	1 6 3
Home-grown corn ...	9 3 11

Purchased feeds were valued at cost price, plus carriage to farm where necessary. Average prices per ton for the general classes specified were : Purchased cakes, £10 17s. 10d. per ton; Purchased meals, £10 6s. 7d. per ton.

The ascertainment of pasturage costs consists of a complex calculation with these items : rent and rates, manures, labour, etc., on pastures, days of cow pasturage, and pasturage of other stock. In only a few cases are cows grazed alone on pastures or aftermath, and then not often all the year round or throughout the possible pasturage season. The pasturage costs shown represent actual costs as nearly as they are ascertainable.

In Group 1 the home-grown foods account for nearly 65 per cent. of the total cost of food; in Group 2 about 56 per cent., and in Group 3 approximately 47 per cent. High costs of milk occur on some of the farms when a low percentage of cost is due for home-grown foods and *vice versa*. In the case of home-grown foods so much depends on the quality of the crops and the quantities fed, and in the case of the purchased foods, their suitability as a food for dairy cows, their food value in relation to price and the time of purchase have to be considered. Even when a proper selection of home-grown and purchased foods has been made to suit the needs of the dairy herd and the general economy of the farm, it does not necessarily follow that the total food cost will be low, because there still remains the problem of feeding the cows with the minimum quantity of food required to maintain them in healthy and breeding condition and to produce the milk which each cow is capable of giving. There is a tendency for home-grown foods to be fed with less regard to economy than those which are purchased. A farmer may have an exceedingly bulky crop of hay, and because hay is plentiful he may be inclined to feed an extra quantity without reducing the other foods and perhaps without any increase in the milk

yield. The summary of the cost of home-grown and purchased foods per gallon of milk produced is as follows :—

Gross cost of food per gallon of milk.

	Home-grown.	*Purchased.*	*Total.*
	Pence.	Pence.	Pence.
Group 1 ...	3.57	2.11	5.68
Group 2 ...	2.69	2.33	5.02
Group 3 ...	2.14	2.77	4.91
All groups ...	2.69	2.44	5.13

These figures refer to the gross cost without any credit being given for manurial residues. No manurial residues are allowed for home-grown food other than corn and meal, and the bulk of the value of the manurial residues is due to purchased foods.

When the credit for manurial residues is taken into consideration, the result is approximately as follows :—

Net cost of food per gallon of milk.

	Home-grown.	*Purchased.*	*Total.*	*Yield per cow in herd.*
	Pence.	Pence.	Pence.	Gallons.
Group 1 ...	3.54	1.91	5.45	487
Group 2 ...	2.67	2.12	4.79	596
Group 3 ...	2.12	2.52	4.64	709
All groups ..	2.67	2.22	4.89	600

From the figures it is evident that a high proportion of costs due to home-grown foods is accompanied by high cost of food per gallon. It must be remembered, however, that there is a difference in yield per cow of over 100 gallons between each of these groups.

When the quantities of food and the cost of pasturage are set out per gallon of milk it is found that the herds with the lower yields (Group 1) consume relatively large amounts of food against their production. This may be due in part to low quality of foods, and to lack of balance in the ration, but it is largely due to the fact that the cows are poor converters of food into milk, *i.e.*, that they have a naturally low yield capacity. In Group 3 there is probably a much better balance in the ration, but there is certainly a high production relative to feed consumed. The cows have naturally a higher yield capacity than those of other groups. There is a very definite difference in yield, and in yield capacity relative to feed consumed between

Groups 1 and 2. The figures are below. Methods of feeding and the natural yield capacities of cows combine to produce the results shown.

Quantities of bulk and concentrated feed and cost of pasturage per gallon of milk.

Group.	*Concentrates.*	*Hay.*	*Straw.*	*Roots and green foods.*	*Total bulk foods.*	*Pasturage per gallon.*
	lb.	lb.	lb.	lb.	lb.	pence.
1	2.54	6.20	1.15	8.57	15.92	2.22
2	2.21	4.22	0.89	7.96	13.07	1.51
3	2.83	4.35	0.59	3.48	8.42	1.28
All groups	2.53	4.73	0.84	6.41	12.01	1.59

It is quite possible that home-grown foods are not fed with the same care as those which are purchased and that rations of the home-grown foods are lavish as long as supplies are plentiful. It is also quite possible that in some cases, especially in Group 1, it would pay to increase the concentrate ration.

Length of rest period.

From statistics of Milk Recording Societies, it has been shown that the average dry period is nine weeks and the average figure for these herds is about the same. In some herds it was less or greater. The length of the dry period has some effect on the cost of milk. If the period of rest and the length of time the cow has to be maintained, but is not producing, is long, and is not compensated for by the increase yielding capacity of the cow, costs will rise. When the dry period is short, immediate costs will tend to fall. If, however, the constitution or the capacity of the cow is impaired, costs will in the long run be higher. The length of the dry period will be connected in some degree with the period of calving. Heavy spring calving will usually mean a comparatively long dry period and heavy calving in autumn or early winter usually leads to a short rest period.

At what period of the year cows can be dry to most advantage is a problem which has not received a great deal of attention. It does seem, however, that when dry cows have to be fed on practically the same ration as milkers that it is a disadvantage to have them dry in mid-winter, when the cost of feed is high and the milk is of more value. But the period of the year

when cows can be dry to advantage will be determined by factors other than the cost of feed per gallon and largely by the value of the milk.

Period of calving.

Of the total number of cows calving in the herds, 474 or 25 per cent. calved during the period September to November, 553 or 29 per cent. during December to February, 492 or 26 per cent. during March to May, and 387 or 20 per cent. during June to August. Thus the proportion of winter calving was 8 per cent. higher than the summer calving and the highest number of calvings occurred during the period December to February.

There have been suggestions and some indications that the season of the year in which most of the cows in a herd freshen

TABLE VIII.

Period of calving (September–November). Yield and cost of home-grown and purchased foods, and grazing per cow and per gallon. (87 herds).

Group.	*No. of Herds.*	*Average No. of Cows in Herds.*	*Yield per Cow in Herd*	*Yield per Cow in Milk.*
			Gallons.	*Gallons.*
Under 20%	34	21.5	605.2	741.7
20%—39%	38	21.7	588.1	698.7
Over 39%	15	16.7	640.8	767.5
Average ...	—	20.8	602.3	725.9

Group.	*Net Cost of Home Grown, Purchased Foods & Grazing per Cow.*	*Net Cost of Home Grown and Purchased Foods per Cow.*	*Net Cost of Home Grown, Purchased Foods & Grazing per Gallon.*	*Net Cost of Home Grown and Purchased Foods per Gallon.*
	£ s. d.	£ s. d.	*Pence.*	*Pence.*
Under 20%	15 9 11	11 8 3	6.15	4.54
20%—39%	16 1 9	12 2 0	6.56	4.94
Over 39%	18 1 8	14 16 2	6.77	5.54
Average ...	16 2 6	12 3 11	6.42	4.86

has much to do with yield and with the cost of production.[1] In the United States it has been found that cows freshening in the fall (September to November) will yield 15 to 20 per cent.

[1] Misner: "The cost of producing milk and some factors influencing the cost". Cornell University, Ithaca, New York.

more milk than those freshening in the spring. The practice with regard to the period when the cows freshen is shown in Table VIII. Three groups were made of the records, one to include herds with less than 20 per cent. of the cows freshening from September to November inclusive, one to include herds with from 20 and under 39 per cent. and one to include farms with over 39 per cent.

The herds with less than 20 per cent. of the cows freshening during the months September to November show a higher milk yield than those of 20 and under 39 per cent. In the case of the herds of over 39 per cent. the milk yield is about thirty-six gallons more per cow in the herd than the herds of under 20 per cent. As regards the net cost of foods per cow and per gallon, the farms with the higher percentage of fall freshened cows show the highest costs.

In Table IX the herds are classified according to the percentage of calvings from September to February.

TABLE IX.

Period of calving (September–February). Yield and cost of home-grown, purchased foods, and grazing per cow and per gallon (87 herds).

Group.	*No. of Herds.*	*Average No. of Cows in Herds.*	*Yield per Cow in Herd.*	*Yield per Cow in Milk.*
			Gallons.	*Gallons.*
Under 50%	30	19.7	598.3	732.2
50%—69%	42	22.5	593.3	701.2
Over 69%	15	17.8	643.4	767.5
Average ...	—	20.8	602.3	725.9

Group.	*Net Cost of Home Grown, Purchased Foods & Grazing per Cow.*	*Net Cost of Home Grown and Purchased Foods per Cow.*	*Net Cost of Home Grown, Purchased Foods & Grazing per Gallon.*	*Net Cost of Home Grown and Purchased Foods per Gallon.*
	£ s. d.	£ s. d.	*Pence.*	*Pence.*
Under 50%	15 12 6	11 7 5	6.27	4.83
50%—69%	16 0 1	12 3 6	6.47	4.92
Over 69%	17 13 2	14 2 5	6.58	5.26
Average ...	16 2 6	12 3 11	6.42	4.86

The herds with under 50 per cent. and those of 50 to 69 per cent. of the cows freshening during the period from September

to February have about the same average milk yield per cow in the herd. On the farms where there are over 69 per cent. of the cows calving during that period, the yield is more by about forty-five gallons per cow. Both as regards yield and cost of feed, the figures show the same general tendencies as in Table VIII.

The argument put forward for fall and winter calving is on the grounds of greater milk yield and the greater yield of butter fat. But the question of the proper arrangement of the calving period depends to some extent on the objective in milk production. If the object is to sell whole milk, then the producer needs to get a fairly heavy winter supply, and will arrange the calving accordingly. On the other hand, if the chief object is cheese production, chiefly from April to October, the late winter calving and spring calving may give the best results.

Moreover, the final economy of production is not to be measured by cost alone, for the last measure is the balance between cost and the price of the product. It may be that the higher cost of feed per gallon which accompanies the relative high autumn and winter calving is more than compensated by the higher prices of milk and produce then obtainable.

Production labour.

The labour expended on the individual herds varied from 102 to 462 hours per cow per annum, with a general average of 211 hours per cow. From other studies which have been made, it was found that labour requirement per cow was about 200 hours.[2] Thus, the average for these herds is slightly more per cow. The variations in the number of hours per cow can be ascribed to a number of factors, such as the size of the herd, the proportion of autumn and winter calving and milking with

TABLE X.

Size of herd and labour hours per cow and cost per cow.

Group.	*No. of Herds.*	*Average No. of Cows per Herd.*	*No. of Hours per Cow.*	*Cost per Cow.*
Size of Herds.	*No.*	*No.*	*No.*	£ s. d.
Under 15	25	9.8	271	7 14 8
15 and under 25	39	19.8	213	6 4 11
25 and over	24	37.3	195	5 14 10
Average	—	21.0	211	6 3 10

[2] "Labour on the Farm". Ruston and Simpson (*Journal of the Ministry of Agriculture and Fisheries*, December, 1922).
"Agricultural Cost Accounts". C. S. Orwin (*Agricultural Economics, Miscellaneous Papers*, Vol. 3, 1923-5, Oxford University Press).

consequent attendance in winter, the convenience of the buildings, both as regards feeding of the cattle and the handling of the milk, and the efficiency of the labour employed.

In Table X the number of hours and the cost of labour per cow has been analysed according to the size of the herds.

As the herds increase in size the hours per cow and the cost per cow diminish. For the smaller farms which have an average herd of about ten cows, the labour requirement is fifty-eight hours more per cow than those herds consisting of about twenty cows. Herds of twenty-five and over require eighteen hours less per cow than the group of herds of fifteen and under twenty-five cows.

In assessing the cost of labour, all family labour not actually paid for in cash has been charged at the current rates of wages for hired workers of a similar class. The cost of production labour (omitting delivery of milk) varies from £2 17s. 11d. to £12 7s. 8d. per cow, with an average of £6 3s. 10d. per cow. The average rate of wages per hour paid for labour in each group of herds in Table X is very similar. For the herds consisting of less than fifteen cows it works out at 6.8d. and for the group of fifteen and under twenty-five and twenty-five and over the rate is 7d. per hour. These rates of wages include those for boys and women as well as men. The labour cost per cow shows a gradual decrease from the smaller to the larger herds.

In Table XI, the herds have again been classified on the same basis to show the labour hours and the cost of labour per 100 gallons of milk produced.

TABLE XI.

Labour hours and cost of labour per 100 gallons of milk.

Group.	*No. of Herds.*	*Average No. of Cows in Herd.*	*No. of Hours per 100 Gallons of Milk.*	*Cost of Labour per 100 Gallons of Milk.*		
Size of Herds.	*No.*	*No.*	*No.*	£	s.	d.
Under 15	25	9.8	47	1	6	7
15 and under 25 ...	39	19.8	36	1	1	2
25 and over	24	37.3	34	1	0	3
Average	—	21.0	37	1	1	5

The average number of labour hours works out at thirty-seven and the cost at £1 1s. 5d. per 100 gallons. There is a decrease in the number of hours and the cost of labour as the herds increase in size.

Attention has already been drawn to the considerable variation that exists in the number of hours and in the cost of labour per cow. It does not, however, follow that high costs of labour are uneconomical. So much depends on whether the labour is efficient and whether it is efficiently used in the feeding and the general management of the herd. There is, however, reason to believe in regard to some of the farms that the labour was in excess of the amounts which should be required under fair conditions. Where buildings are well arranged for the purpose of feeding and cleaning the cows, and the handling of milk, the amount of labour on the herds is reduced. On the other hand, on many farms the arrangement of the buildings from this point of view leaves much to be desired and the high labour cost on some of these farms was influenced to an appreciable extent by the lack of really suitable and convenient buildings.

Again, there is the question of economy of high and low wages, but owing to the influence of the buildings and equipment on efficiency, it is difficult to draw any conclusions on this point. The average rate of wages per farm varied from 5d. to 11d. per hour. The lower rates are closely related to the amount of work done by women and boys. There are cases where the rates of wages are high and the labour costs are comparatively low and *vice versa*. It is really not a question of whether the rates of wages are high or low, but the thing that does matter is whether the labour is efficient and if it is efficient, then the higher rates may represent relatively cheap labour.

Receipts and expenses.

Returns for the receipt of milk were only obtained for sixty-three cases. Receipts vary according to the methods of selling, and the price received for the milk. The method of disposal of the milk is shown in Table XII.

TABLE XII.

Method of disposal of milk over three years.

	%	%
Wholesale ...	65.92	
Retail ...	11.86	
		77.78
Butter making ...	9.62	
Cheese making ...	4.86	
Household ...	2.61	
Calf rearing ...	3.76	
Other milk ...	1.37	
		22.22
		100.00

Allowing for the fact that general estimates of production and use of milk in England and Wales do not include that used

for calf rearing, these proportions are just about equal to those estimated for the destinations of the general supply in England and Wales.[3]

The figures show that approximately 78 per cent. of the total milk produced was destined for the wholesale and retail trade. The balance of 22 per cent. was mainly utilised for the making of butter and cheese, for household purposes, and the rearing of calves.

A summary of the receipts and expenses for the sixty-three cases is given in Table XIII.

TABLE XIII.

Receipts and expenses.

	Per Cow. £ s. d.	*Per Gallon. Pence.*		*Per Cow.* £ s. d.	*Per Gallon. Pence.*
Gross Cost of Production	27 18 0	10.70	Receipts for Milk and Milk Products	36 17 6	14.14
Delivery Cost ..	2 4 8	0.86	Calves and Manurial Value of Foods ..	2 13 7	1.03
Total Expenses ..	30 2 8	11.56			
Balance	9 8 5	3.61			
	£39 11 1	15.17		£39 11 1	15.17

The lowest receipts corresponding to the average above were £19 17s. 6d. per cow and 8.4d. per gallon on a butter producing farm. The highest receipts were £70 12s. 8d. per cow and 24.5d. per gallon. In this case all the milk was retailed.

There does not appear to be any relation between the size of the herds and the " balance " per cow as will be seen from the following figures :—

No. of Herds.	*Size Group.*	*Average number of Cows in Herd.*	*Yield per Cow in Herd.*	*" Balance " per Cow.*	*" Balance " per Gallon.*
		No.	*Gallons.*	£ s. d.	*Pence.*
19	Under 16 ...	10.2	614	5 10 8	2.16
21	16 & under 22 ...	19.0	633	12 4 9	4.64
23	Over 22	34.9	617	8 17 3	3.45
63	—	22.0	621	9 8 5	3.61

The total expenses averaged £30 2s. 8d. per cow and 11.56d. per gallon, with variations of from £16 10s. 4d. to £47 per cow and from 5.1d. to 15.6d. per gallon. The difference between the receipts and expenses averaged £9 8s. 5d. per cow and

[3] See " Report on Agricultural Output of England and Wales, 1925 ". page 65.

8.61d. per gallon. This varied from a deficit of £2 18s. 8d. per cow and 1.5d. per gallon to a surplus of £35 14s. 6d. per cow, and 12.4d. per gallon. The balance as stated represents the sum left over to cover interest on capital, cost of management, and profits.

The herds of sixteen and under twenty-two show the highest "balance" per cow and per gallon. Probably the surplus of receipts over expenses will be influenced more by the method of selling milk than by the size of the business. This appears to be the case when the herds are classified according to the percentage of milk sold as liquid milk. The figures are as follows :—

Method of Disposal.	*No. of Cases.*	*Average number of Cows in Herd.*	*Yield Per Cow in Herd.*	*"Balance" per Cow.*	*"Balance" per Gallon.*
	No.	*No.*	*Gallons.*	£ s. d.	*Pence.*
Over 50% sold as Liquid Milk ...	53	22.1	613	9 14 11	3.8
Under 50% sold as Liquid Milk	10	21.4	667	7 8 5	2.6

These results indicate that those farms producing mainly for the liquid milk trade show the highest "balance" per cow and per gallon.

There can be little doubt that to produce milk at low costs and thereby obtain higher profits in the production of milk, it is necessary to secure a combination of good management on all the items relating to costs. The points which may be emphasised are :—

(1) Attention to the yield of milk.

(2) Care of the health of the herd and the management of the herd in order to avoid a high rate of depreciation and if possible to secure an appreciation.

(3) The arrangement of a ration so as to secure the best results in the yield of milk from the food consumed.

(4) Good but economical farming in the production of home-grown foods. Also care in the preparation and feeding of home-grown foods to avoid waste.

(5) The proper construction of buildings and the provision of the necessary equipment.

(6) The exercise of great care in the selection of the attendants on cows and the proper organisation of the labour employed.

From 1920 to 1927 numbers of cows in dairy herds in England and Wales, and in Wales itself rose nearly 20 per cent.

There has since been considerable decline, probably indicative of falling profits or of expectations of falling profits in this enterprise. If an increase should again occur, or the market for milk become weaker, the relatively inefficient producers may find themselves in difficulties, and it is desirable that the pursuit of practical efficiency on the farms should continue.

COST ACCOUNTS ON A CHEESE FARM.

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This cheese-making farm, situated near the English border, is not representative of much of the farming in the Principality, but it has features which are representative of other farms in the area. The land is productive, easily cultivated and well suited for arable crops and rotation pasture. The farm buildings are adequate and well arranged and the layout of the fields could hardly be improved upon. This compact holding is within two miles of one of the most prominent border towns, where all the produce from the farm is marketed easily. Primarily the holding is a dairy farm, where the milk is produced for the main purpose of making Cheshire cheese. The farm is in a high state of cultivation and the business is conducted on sound and modern technical methods. Milk recording is practised and all the cows are rationed according to yield of milk. It appeared that it would be useful to examine the degree to which this well-equipped farm has repaid the attention devoted to it by the management over three years' farming.

Detailed cost accounts were commenced on the farm in April, 1927. In addition to recording details of financial transactions, the farmer kept accurate records of disposal of all home grown foods to the various classes of stocks, utilisation of man and horse labour time by crops and stock, disposal of manures and seeds, and use of milk for different purposes. At all times as much attention was paid to quantitative records as to actual cash values of transactions.

The completeness and accuracy of the records is a great tribute to the care devoted to them by the farmer himself. It is not easy to find working farmers who are interested in the analysis of processes and transactions on the farm in terms of figures and quantities, but it is far more difficult to find farmers who enjoy handling figures.

The system of cost accounts adopted in this case was based on the principles laid down by Orwin and the same methods were followed for each year. All valuations where possible were made on the cost of production basis. Manurial residues were allocated according to the Voelcker and Hall standard tables, and foodstuffs residues were calculated according to standards used in the *Journal of the Ministry of Agriculture.*[1]

Land utilisation.

The land on the farm is light and easily cultivated and with the exception of eight acres of rough grazing it is all available for cultivation and crop production.

Land utilisation.

Arable Crops.	1927. *Acres.*	1928. *Acres.*	1929. *Acres.*	*Average Acres.*	%
Wheat	—	—	4.0	1.3	0.9
Oats...	12.6	10.0	9.6	10.7	7.2
Mixed Corn ...	8.0	10.3	8.6	9.0	6.0
Sugar Beet... ...	2.0	3.0	3.0	2.7	1.8
Potatoes	4.5	6.5	4.0	5.0	3.4
Mangolds	1.5	1.5	1.3	1.4	1.0
Swedes	1.0	0.7	0.8	0.8	0.6
Rape	—	—	1.0	0.3	0.2
Kale	1.0	0.7	1.0	0.9	0.6
Total Tillage ...	30.6	32.7	33.3	32.1	21.7
Mown for Hay ...	40.5	38.5	38.2	39.1	26.5
Pasture	68.7	68.6	68.3	68.6	46.4
Rough Grazing ...	8.0	8.0	8.0	8.0	5.4
Total Acreage...	147.8	147.8	147.8	147.8	100.0

The rotation of crops and grass adopted on the farm covers a term of seven or eight years. A corn crop, either wheat, oats, or mixed corn, is planted in the ploughed ley-land and this is followed by the root break, which consists of potatoes, mangels, swedes, and sugar beet, which in recent years has taken over some of the acreage formerly occupied by swedes and turnips. In the third year grass seeds are sown with a nurse crop of either barley or oats. The seeds are mown in the first harvest year for hay and grazed by stock for the following three or four years. All the grass leys are temporary and they are ploughed up when the quality of the sward shows signs of deterioration.

[1] Monthly article, " Notes on Feeding Stuffs ".

Ownership and rental value.

The farm with some additional land was purchased in 1920 at a price which represented about thirty years' purchase on the gross rental. The additional land is let, and its results do not enter into the farm accounts, but transactions relating to it enter into the estate account. The farm and additional land were not wholly paid for out of existing capital, and the high price, together with loan costs and ownership charges are estimated to have raised the necessary charge for rent by about £100 per annum—a very heavy increase on a farm of this size. The estate account, average of three years, is conventionalised below. The actual figures cannot be given.

Estate management account.

	Percentage Distribution Average Three Years.
EXPENSES.	
Tithes	5.4
Loan Charges	81.2
Repairs	5.7
Labour and Sundries	7.7
RECEIPTS.	
Sundry Sales	3.4
Rents Received	79.4
Net Loss	17.2
	100.0

The rent charge on the farm account after deducting residential value of house averaged £2 1s. 1d. per acre. Nevertheless there was a loss on the estate account each year which averaged £91 19s. 10d. While the estate account showed this average loss, the total of the farm accounts showed an average profit of £200 5s. 10d. and the net results of ownership and of occupation showed an average net profit of £108 6s. (see p. 61).

The farm business.

Farm capital.

The method of standard valuation was adopted wherever possible in respect of livestock, while all crops and other "deadstock" were carried forward in the balance sheets at cost of production or at cost and depreciation.

The total valuations for each year were nearly £20 per acre, which indicates very heavy capitalisation and intensive farming. Livestock capital was £10 7s. per acre on the average and crops and produce £8 11s. 1d. per acre. Capital invested in implements

Distribution of capital.

	Average 3 Years.			*Per Acre.*			%
	£	s.	d.	£	s.	d.	
Dairy Cows	441	16	8	2	19	8	13.8
Other Cattle	267	6	6	1	16	2	8.3
Horses	45	0	0	0	6	1	1.4
Sheep	505	3	9	3	8	3	15.8
Pigs	260	3	9	1	15	2	8.1
Poultry...	12	14	6	0	1	8	0.3
Total Livestock	1,532	5	2	10	7	0	47.7
Implements	602	3	11	4	2	0	18.9
Stores	120	14	1	0	14	8	3.4
Crops and Produce	526	18	3	3	11	1	16.4
Total Valuation	2,782	1	5	18	14	9	86.4
Cash in Hand...	32	3	2	0	4	4	1.1
Sundry Debtors	401	15	6	2	14	3	12.5
Total Assets	3,216	0	1	21	13	4	100.0
Deduct Creditors	503	16	1	3	8	1	15.7
Capital	2,712	4	0	18	5	3	84.3

was abnormally heavy, although depreciation was allowed at the rate of 10 pen cent. each year. The farm was very well equipped, both for crop production and livestock management. All the outbuildings are fitted with electric light and the field implements are modern in type. The older machines are very infrequently used, although carried forward in the valuations.

Much of the farm produce was sold in comparatively small quantities to shops and householders and as a result the list of debtors was elaborate and cumbersome to handle. The amounts shown for sundry creditors is typical of conditions on many farms. Bills remain unpaid for comparatively long periods, making the actual work in accurate book-keeping more tedious than would otherwise be necessary.

Receipts and expenses.

The Profit and Loss Account in a costs scheme provides little information with which to picture the farming system, and for this purpose a financial statement has been extracted for each year. The principal sources of income were clearly the sale of livestock, particularly sheep and pigs, and of livestock products, mainly liquid milk and cheese. The sheep enterprise can be treated apart from the other farm enterprises and its profitability

estimated separately. In the case of the dairy, however, the procedure cannot be so simple or the issue so clearly defined. The principal product for sale was cheese, and whey, a by-product from the dairy, was the foundation of the pigs enterprise.

Summary of Receipts and Expenses, 1927-30.

RECEIPTS.	1927—8.	%	1928—29.	%	1929—30.	%	1927—30. *Average.*	%
	£ s. d.		£ s. d.		£ s. d.		£ s. d.	
LIVESTOCK SOLD.								
Cattle	283 8 7	11.1	97 5 2	3.4	400 9 10	13.5	260 7 10	9.3
Sheep	497 13 8	19.4	747 19 0	26.5	739 12 2	24.9	661 14 11	23 8
Pigs	642 16 6	25.1	606 16 6	21.5	764 14 0	25.7	671 9 0	24.1
Poultry	2 6 3	0.1	1 11 11	0.1	3 11 0	0.1	2 9 9	0.1
Dairy Products	666 0 6	26.0	700 10 2	24.9	658 3 2	22.1	674 17 11	24.2
Eggs	42 13 3	1.7	51 10 2	1.8	40 8 0	1.4	44 17 2	1.6
Wool	33 16 4	1.3	42 11 6	1.5	22 3 6	0.7	32 17 2	1.2
Crops	336 4 9	13.1	509 2 8	18.0	309 1 4	10.4	384 15 6	13.8
Sundries	57 6 6	2.2	65 11 4	2.3	37 4 9	1.2	53 7 7	1.9
Total Sales	2,562 6 4	100.0	2,822 18 5	100.0	2,975 7 9	100.0	2,786 16 10	100.0
EXPENSES.	—	—	—	—	—	—	—	—
LIVESTOCK.								
Cattle	—	—	—	—	22 7 0	0.9	7 9 0	0.3
Sheep	181 16 4	7.9	332 16 6	13.3	227 10 5	8.9	247 7 9	10.0
Pigs	94 19 0	4.2	109 16 6	4.4	275 18 3	10.8	160 4 7	6.6
Poultry	—	—	3 15 0	0.2	0 5 0	0.0	1 6 8	0.1
TOTAL LIVESTOCK PURCHASES	276 15 4	12.1	446 8 0	17.9	526 0 8	20.6	416 8 0	17.0
Purchased Foods	713 19 6	31.2	664 15 4	26.6	587 11 2	23.1	655 8 8	26.8
Manures	42 11 6	1.9	55 12 2	2.2	100 1 0	3.9	66 1 6	2.7
Seeds	15 16 11	0.7	30 7 7	1.2	47 14 6	1.9	31 6 4	1.3
Stores	41 9 3	1.8	65 0 3	2.6	52 0 0	2.0	52 16 6	2.2
Rent, Rates and Insurance	411 3 1	18.0	384 1 2	15.4	343 18 3	13.5	379 14 2	15.5
Manual Labour	673 4 5	29.4	691 14 5	27.7	710 9 10	27.9	691 16 3	28.3
Equipment and Repairs	20 15 5	0.9	33 5 8	1.3	26 6 7	1.0	26 15 11	1.1
Sundry Expenses	91 14 10	4.0	128 18 1	5.1	153 8 11	6.1	124 13 11	5.1
TOTAL	2,287 10 3	100.0	2,500 2 8	100 0	2,547 10 11	100.0	2,445 1 3	100.0

Again the maintenance of the dairy herd was very closely connected with the "other cattle" account, where the costs

of rearing heifers were recorded. It was only possible to estimate profitability therefore by dealing with this complex enterprise in one whole, taking the dairy account, the other cattle account, and the pigs account together.

Purchases were substantial in both the pigs and sheep accounts and the output in these sections was materially different from actual sales in cash. Practically all the cattle were home-bred and reared, and sales of cattle and dairy products give a good indication of output.

Although the farm was very highly capitalised, sales in each of the three years were almost equal to the total assets (excluding cash and debtors), and the average sales over the period were £2,786 16s. 10d., as compared with assets £2,782 1s. 5d. The heavy sales per acre each year at £17 6s. 5d., £19 1s. 7d., £20 1s. 10d., should be noted.

Analysis of some expenditure accounts.

Manual labour.

The labour account was charged with the wages paid to hired workmen and with the value of work done by members of the family. For the greater part of the period two sons worked regularly on the farm and the farmer himself was included in the labour staff when he was actually engaged in manual tasks and his time charged to the account at the ordinary rates of wages. In all, four men were employed, and one dairy maid was partly employed in cheesemaking and partly in domestic duties. Six adults were fully and regularly engaged. The total labour cost over the period and the average distribution of labour time over the different farm enterprises is given below.

Total cost of labour.

Year.				*per acre.*		
	£	s.	d.	£	s.	d.
1927-28	744	7	7	5	0	7
1928-29	756	18	7	5	2	3
1929-30	748	19	3	5	1	2
Average	750	1	10	5	1	4

Deducting the labour charges for contract work, estate, private, and garden, the net average labour charge on the farm was £691 16s. 8d., equal to £4 13s. 6d. per acre. The total hours of work for farm operations was 19,631, or 133 hours per acre.

Annual distribution of manual labour over three years.

Livestock.	*Hours.*	*Cost.*	%
		£ s. d.	
Dairy Cows	7,135	231 5 11	30.8
Other Cattle	661	23 15 0	3.2
Horses	465	16 17 2	2.2
Sheep	1,330	48 0 8	6.4
Pigs	976	35 7 6	4.8
Poultry...	162	3 6 2	0.4
Total Livestock	10,729	358 12 5	47.8
Crops	6,202	225 1 7	30.0
Establishment...	1,747	63 3 5	8.4
Subsidiary Accounts	953	34 16 0	4.6
Contract Work	328	11 17 11	1.6
Estate	780	28 3 10	3.8
Garden and Private	833	28 6 8	3.8
Total	21,572	750 1 10	100.0

Horse labour.

Only a sufficient number of work horses were kept to deal with the farm operations and to satisfy the peak demands for labour; horses were maintained for efficiency in work with the minimum of cost. Over the three years, with the exception of the last six months of the period, three work horses were kept. The average number over the period was 2.8.

Average costs of maintenance per working horse.

	£ s. d.	%
Food.		
(*a*) Home grown	9 4 6	34.3
(*b*) Purchased	4 19 11	18.6
(*c*) Grazing	3 7 7	12.6
Manual labour	5 19 1	22.2
Saddlery	0 16 5	3.0
Shoeing	1 5 9	4.8
Depreciation on harness and repairs	0 12 9	2.4
Miscellaneous	0 11 1	2.1
Total	26 17 1	100.0

Home-grown foods were charged to horses at cost of production in each case. The quantities of food consumed per working horse were

	Oats. *Cwt.*	*Hay.* *Cwt.*
1927-28	11	26
1928-29	12½	46
1929-30	13	15
Average	12	30

On the returns side of the "working horses" account appear the different farm departments to be charged with the cost of maintenance of horses according to amount of horse work done. The distribution of horse hours is set out in summary below.

Average distribution of horse labour.

	Hours.	*Cost.*	*% of Cost.*
		£ s. d.	
Livestock	427	8 17 1	11.7
Arable Land	2,432	50 9 1	67.2
Hay	402	8 6 10	11.2
Pasture	67	1 7 11	1.8
Establishment	81	1 13 9	2.2
Subsidiary Accounts	57	1 3 9	1.6
Estate	87	1 16 3	2.4
Private	18	0 7 6	0.5
Contract Work	52	1 1 8	1.4
	3,623	75 3 10	100.0

Over the whole period the number of hours' work done per horse per year was 1,294, or 162 days of eight hours, giving an average cost of approximately 5d. per work hour.

Cost of raw materials.

The three main items of raw materials imported on to farms are feeding stuffs, fertilisers, and seeds, and the requirements under these heads varies both with the farming system and with the intensity of husbandry. On this farm consumption of feeding stuffs was heavy, cash purchases amounting on the average to £655 8s. 8d., or £4 8s. 8d. per acre. Expenditure was reduced to some extent in each successive year, as shown by these figures: (1) £4 16s. 7d; (2) £4 9s. 11d.; (3) £3 19s. 6d. per acre.

The principal foods consumed with average yearly quantities are given below.

	Tons.
Oilseed cakes and meals ...	31.4
Bran	6.4
Cereal meals	14.1
Fish meal	1.2
Uveco	4.9
Beet pulp	2.5
Treacle	0.3
Minerals, condiments, etc.	1.1
Total	61.9

Generally speaking, the oilseed cakes and meals were fed to the dairy cows; the cereal meals, fish meal, and Uveco to the pigs and poultry.

The average application of fertilisers was relatively small in each year, costing £66 1s. 6d., or 9/- per acre. The quantities of the different classes of manures applied were

	Tons.	*Cwt.*
Superphosphate	3	15
Sulphate of Ammonia ...	1	2
Steam Bone Flour	3	13
Sulphate of Potash ...	0	13
Compound manures ...	0	13
Salt	0	5
	10	1

As expenditure on purchased foods was reduced, that on fertilisers was increased each year, as follows: (1) 5s. 9d.; (2) 7s. 6d.; (3) 13s. 6d. per acre.

Expenditure on seeds was not heavy over the period, but it varied from year to year according to the area of land to be laid down to grass. Other materials purchased and used consisted of binder twine, fencing equipment, and various consumable supplies.

The average cost of raw materials used in each year amounted to £805 13s., or £5 8s. 10d. per acre; more than double the rental charge and greater than the total cost of labour.

Some of the subsidiary accounts entering into total expenses are interesting in analysis of cost and distribution of charges. This farmer kept a tractor for use in periods of stress on the farm and for haulage purposes on estate account. The unit is now old and it is only valued at a nominal figure in the accounts, but it is efficient for the purposes for which it is maintained.

Cost of maintenance of tractor.

	1927.			1928.			1929.			*Average.*		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Repairs and Labour .	2	17	2	1	0	3	5	10	6	3	2	8
Tax	0	5	0	0	5	0	0	5	0	0	5	0
Oils and Fuels ...	10	19	3	16	18	6	15	9	7	14	9	1
Depreciation	5	0	0	4	0	0	3	4	0	4	1	4
	19	1	5	22	3	9	24	9	1	21	18	1
Total Hours Worked	127			236			187			181		
Cost Per Hour ...	3/-			1/11			2/7			2/5		

All the sundry expenses which occur in farm accounts, such as various general subscriptions, telephone, postages, water rate, some general insurances, with labour done on general farm work

which could not be allocated to a definite account, were included in the establishment account and apportioned over the productive accounts of livestock and crops on the basis of the amount of manual labour directly utilised by each enterprise. The average charge on establishment account for the three years was 18s. 9d. per acre, or a total overhead charge of £141 7s. 3d. over the farm.

Productive Accounts—Livestock and Crops.

Dairy Herd Account.

Management of the dairy herd for milk production was the principal enterprise on the farm, and the success or otherwise of this section determined to a large degree the nature of the results of the business as a whole. For the first two years of the period, things went smoothly with the dairy herd, the cows were healthy and milk yield was satisfactory. In the third year, however, contagious abortion set in and a number of cows had to be disposed of, disorganising the system of breeding and management and causing the farmer a great deal of trouble and financial loss. The full incidence of the loss through disorganisation will not be apparent until the accounts for the current year (1930-31) are examined, and possibly it will be felt for some years to come; but it does not seriously affect the three years' accounts here reviewed.

In the accounts, the dairy herd was charged with all foods consumed at cost, and credits were given for manurial residues, and calves transferred to "other cattle" account. Over the three years the average number of cows in the herd was twenty-two, with an average milk yield of 721 gallons. All the milk during the months March to October was made into cheese, while a proportion of the winter supply was sold wholesale. A small proportion was sold at retail price. The monthly distribution of the milk supply over the three years was

	%		%
January	3.8	July	11.7
February	6.5	August	10.2
March	9.6	September	7.8
April	10.4	October	5.8
May	14.2	November	3.8
June	12.9	December	3.3

All the whey was used for pig feeding and charged to that account at a flat rate of one penny per gallon. This is a conventional charge and the figures of quantities are of more value for some purposes than the conventional value.

Cost of Milk Production—average three years.

	Total Cost.	*Cost per Cow.*	*Cost per Gallon.*	%
	£ s. d.	£ s. d.	d.	
Home Grown Foods	141 5 1	5 19 1	2.13	18.1
Purchased Foods	216 12 9	9 2 8	3.28	27.8
Pasture	100 2 4	4 4 5	1.52	12.9
Manual Labour (including cheese-making...	231 5 11	9 15 0	3.50	29.7
Horse Labour	4 11 1	0 3 10	0.07	0.6
Vet	1 16 5	0 1 6	0.03	0.2
Subscriptions	5 17 0	0 4 11	0.14	0.7
Overhead charges (implements and Establishment)	67 17 4	2 17 3	1.03	8.7
Sundries	9 9 5	0 8 0	0.09	1.3
Gross Cost	778 17 4	32 16 8	11.79	100.0
Deduct Credits for Manure, Calves, and Herd appreciation. ...	105 19 1	4 9 4	1.60	13.6
Net Cost	672 18 3	28 7 4	10.19	86.4

Some extra costs were incurred in cheesemaking, the details of which were :

	£ s. d.
Calico and Small Utensils	6 11 2
Soda	0 13 8
Salt	1 2 0
Rennett Starter and Colouring Matter ...	4 0 7
Subscriptions	2 2 0
Sundries	0 3 6
Total	£14 12 11

The total milk produced over the period was 47,540 gallons, of which 35,000 was converted into cheese.

Cheese cost and returns—totals three years.

Net cost of Milk	10.19	pence per gallon.
Add special Cheese Costs	0.30	,, ,, ,,
Total Cost of Milk for Cheese ...	10.49	,, ,, ,,

35,500 Gallons of Milk produced 35,617 pounds of cheese.

	£ s. d.
Cash Receipts from Cheese ...	1,516 2 1
Add value of Whey	116 19 3
Total Receipts	£1,633 1 4
Total Cost of Cheese made ...	1,551 13 0
Net profit for three years	£81 8 4 = £27 2 9 per year.

The actual cost per pound of cheese over the period was 10.45 pence, while the cash returns amounted only to 10.22 pence. The average prices per pound received for cheese were 10.0d. in 1927-28, 11.25d. in 1928-29, and 9.25d. in 1929-30. Costs of milk production were fairly constant for the first two years, but were higher in the third year. High costs coupled with the low prices received for cheese in the last year brought about a loss which offset half the profits earned in the two previous years.

Taking the whole enterprise (cheese and milk sales), the results shown for the three years were

	£	s.	d.	
1927-28	126	8	1	— profit.
1928-29	99	14	9	— profit.
1929-30	112	4	11	— loss.
Total net profit for three years	113	17	11	

Of this total, £81 8s. 4d. was contributed by cheese, and the remainder, £32 9s. 7d., came from milk sales.

The above statement of profits earned does not provide an accurate picture of the economics of the dairy herd. The policy of the farmer has been to breed and rear all his own heifers for drafting into the herd. This enterprise, which in the costings was dealt with in the other cattle account and separate from the milk production account, was a source of serious loss in each of the three years. There were only few purchases of cattle, and sales consisted of surplus calves with a few heifers not of the type desired for herd maintenance. Heifers drafted into the dairy herd were credited to that account at a flat rate of £20 each. The losses incurred on this section demonstrate plainly the inadequacy of the charge made on the dairy account for each heifer drafted in. Net losses on other cattle account were

	£	s.	d.
First year	115	0	9
Second year	71	10	10
Third year	49	8	5
Total three years	£236	0	0

Again, the analysis of the dairy account cannot be concluded without introducing the results obtained from the pigs enterprise. All the whey was fed to pigs and charged at the rate of one penny per gallon. The greater proportions of the pigs were purchased as stores and sold for pork or for bacon. In the first year the pigs account showed a net loss of £3 15s. 10d.; in the second a profit of £91 6s. 10d. was realised, and this was increased in the third year to £270 17s., a total profit over the three years of £358 8s.

Placing the three accounts, dairy cows, other cattle, and pigs, together for the period, the following results appear :

Profits and losses on three accounts.

	First year.	*Second year.*	*Third year.*	*Total three years.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Dairy ...	+ 126 8 1	+ 99 14 9	− 112 4 11	+ 113 17 11
Pigs ...	— 3 15 10	+ 91 6 10	+ 270 17 0	+ 358 8 0
Other cattle	— 115 0 9	— 71 10 10	— 49 8 5	— 236 0 0
Total profits	+ 7 11 6	+ 119 10 9	+ 109 3 8	+ 236 5 11

The variations in results showed by the pigs account were due almost entirely to variations in prices both of store and fat pigs. These three years included nearly eighteen months of the downward course and a similar period of the upgrade of a typical cycle in pig prices.

Some of the subsidiary information obtained from the cost records relating to the dairy herd management is interesting.

	First year.	*Second year.*	*Third year.*	*Average.*
	lb.	lb.	lb.	lb.
Quantity of home-grown foods fed per gallon (excluding pasture) ...	11.0	10.3	11.5	10.9
	d.	d.	d.	d.
Value of home-grown foods per gallon	1.93	2.19	2.30	2.14
	lb.	lb.	lb.	lb.
Quantity of purchased foods used per gallon	3.02	2.91	2.89	2.94
	d.	d.	d.	d.
Value of purchased food per gallon ...	3.18	3.45	3.21	3.28

Sheep.

The sheep enterprise on the farm consisted mainly but not entirely of breeding for fat lamb production. For this purpose a small flock of Suffolk and a larger flock of Welsh ewes were maintained. In the first year there were forty-two Suffolk ewes and seventy Welsh ewes, but the policy over the period has been gradually to do away with the former and increase the latter in number. At the close of the period there were twenty-six Suffolk and 124 Welsh ewes. In addition to the ewe flock, a small number of store lambs were purchased every year and fattened during the winter on some roots and concentrates.

In only one year was the sheep account able to contribute to farm profits. In the first year a small profit of £21 0s. 5d.

was shown, while in the second and third years actual losses were incurred of £48 19s. 11d. and £74 19s. 8d. respectively, a net loss over the period of £102 19s. 8d.

Sheep costs and returns—average three years.

	£	s.	d.	%
Purchased Sheep...	243	12	11	32.8
Labour	48	0	8	6.6
Horse Labour	4	4	2	.6
Home Grown Foods	61	11	2	8.3
Purchased Foods	52	8	5	7.1
Pasturage...	159	7	10	21.4
Overhead Charges	32	15	2	4.4
Sundries	25	19	4	3.5
Decrease in Valuation	114	8	8	15.3
Total Costs	742	8	4	100.0
Sheep and Lambs sold...	661	14	7	89.1
Wool sold	32	17	1	4.5
Sundry Sales and Receipts	13	10	3	1.8
Balance—Loss	34	6	5	4.6
	742	8	4	100.0

It is difficult to explain the persistency of losses on the sheep account. Sheep have been regarded in Wales as the most profitable enterprise in mixed husbandry in recent years. It is questionable, however, whether the policy of substituting Welsh for Suffolk ewes has been wise. Judging by results, the contrary appears to be true, although the increase in losses can be explained partly by the decline in prices of mutton and lamb over the period. With the high expenditure on labour and concentrated foods, both home-grown and purchased, shown in the sheep account, it is doubtful whether a flock of Welsh ewes can show sufficient turnover in lamb sales to cover expenses. They are maintained on land of superior quality, but which is expensive, and the cost of pasture was necessarily high at £3 19s. 4d. per acre or £1 4s. 7d. per breeding ewe.

Poultry.

In contrast to the sheep account, the small flock of hens, numbering on the average sixty-three, showed a surplus of receipts over expenditure each year.

Poultry costs and returns—average of three years.

	£	s.	d.	%
Poultry Bought	1	6	8	2.8
Home-Grown Foods	8	9	10	17.9
Purchased Foods	6	0	11	12.8
Labour	3	6	7	7.0
Overhead Charges	2	2	10	4.7
Decrease in Valuation	2	8	9	5.1
Net Profit	23	11	3	49.7
	47	6	10	100.0
Poultry sold...	2	9	9	5.2
Eggs sold	44	17	1	94.8
	47	6	10	100.0

Cost of production of crops.

On this farm one-seventh of the cost of production of the grain crops has been allocated to straw and the remaining six-sevenths to grain. But the division is arbitrary and may lead to inaccurate deductions when crop costs are apportioned to the livestock departments.

Greater difficulty or unreality may arise from the attempted allocation of manurial residues to succeeding crops. On this farm the basis for such distribution was Voelcker and Hall's tables, and these were adhered to over the whole period. The method is cumbersome in accounting and the results tend to give the impression of unreality. Again the choice lies between obtaining information (although some parts of it may only be estimated) about each individual crop in each year and getting a broad picture of the rotation as a whole or of a succession of crops.

Cereals.

In the main, the cereal crops were grown for stock feed. Small quantities were sold to neighbours, small holders and cottagers, but only small consignments of wheat were sold in the market. In the schedule of costs for each crop the information relating to labour in cultivation is based on the detailed records contained in the time sheets. The amounts of seeds, both purchased and home grown, were recorded and entered into the accounts at purchase price or in the case of home grown seed at cost of production. The cost of fertilisers is a net charge after allowing for residues carried forward to succeeding crops.

Cost of production of cereal crops per acre—average three years.

	Mixed Corn.	*Wheat.**	*Oats.*	*Average all Cereals.*
Total Acreage	26.8	4.0	32.2	63.0
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Manual Labour	1 11 4	4 4 5	1 19 2	2 11 8
Horse	0 15 5	1 15 6	1 2 3	1 4 5
Tractor	0 4 4	0 7 10	0 3 2	0 5 1
Total Labour	2 11 1	6 7 9	3 4 7	4 1 2
Fertilisers	1 10 2	0 8 0	0 2 5	0 13 6
Seed	0 9 5	1 16 7	0 11 6	0 19 2
Rent and Rates	2 5 8	2 5 9	2 5 7	2 5 8
Establishment	0 5 11	0 8 1	0 6 10	0 6 11
Threshing and Implements ...	1 12 11	1 2 11	1 16 8	1 10 10
Net Cost of Crop	8 15 2	12 9 1	8 7 7	9 17 3
Deduct value of Straw ...	1 5 1	1 15 8	1 3 11	1 8 3
Net Cost of Grain	7 10 1	10 13 5	7 3 8	8 9 0
Yield per Acre (Cwt.) ...	28	29	30	29
Net Cost per Ton	£5 6 4	£7 7 2	£4 13 3	£5 16 6

* Wheat was only grown in one year.

The overhead charges such as rent and rates and implements depreciation were each apportioned on a flat rate per acre, and establishment on the basis of direct labour requirements.

Costs per acre of growing the various crops varied only slightly from year to year, while yields and consequently costs per unit of grain fluctuated according to the nature of the season. For 1927, 1928, and 1929, the yield per acre of oats was 32 cwt., 26 cwt., and 33 cwt., and the cost per ton of oats £4 19s.; £5 1s., and £3 19s.

Root crops.

The root break on this farm is typical of conditions generally on Welsh farms. It is an important part of the rotation of crops, serving to clean the land, and to prepare the ground for laying down to temporary pasture. On this farm practically all the farmyard manure was applied to these cleaning crops and there is no attempt in the analysis of cost to estimate profitability of these crops. They serve a complex and important function in the farming system and it is not practicable to attempt to dissociate them from other enterprises in which they form a part.

The root break consisted of four crops. Part was devoted to swedes and mangels grown entirely for stock feed and part to potatoes and sugar beet, grown primarily for sale.

Cost of production of swedes and mangels per acre—average three years.

Items in Cost.	*Swedes.*	*Mangels.*
	£ s. d.	£ s. d.
Manual Labour	6 9 4	8 15 5
Horse Labour	3 2 10	2 11 3
Tractor	0 10 0	0 5 7
Fertilisers	2 5 5	2 19 11
Farm Yard Manure	4 8 0	5 1 9
Seeds	0 6 3	0 14 1
Rent and Rates	2 5 9	2 5 5
Establishment	1 7 11	2 2 11
Sundries	1 4 8	1 0 9
Total	22 0 2	25 17 1
Deduct Manurial Residues	2 9 3	3 1 1
Net Cost	19 10 11	22 16 0
Yield per Acre	21.6 tons	24.2 tons
Net Cost per Ton	0 18 1	0 18 10

Unfortunately it was not possible in any year to obtain reliable figures of the cost of growing potatoes, an important cash crop on this farm and the most important in the root break. Transactions in production of potatoes were mixed up with transactions of outside purchase and sale, with the result that it was impossible to assess the cost of growing the crop or the actual returns made by the potatoes grown on the farm. Taking the potatoes account as a whole in each year it showed a substantial profit, derived partly from trading and from growing the crop for sale.

Sugar beet was introduced into the crop rotation for the first time in 1927, when two acres were planted. In the last two years of the accounting period this was increased to three acres. The addition of this crop did not involve an increase in total tillage acreage, it only displaced a proportion of swedes and mangels, leaving the same acreage under total root break.

The net cost per acre showed very little variation from year to year, being £32 16s. 6d. in 1927; £31 14s. 4d. in 1928, and

Costs of growing sugar beet—average of three years.

	Per Acre.			*Per Ton.*			
	£	s.	d.	£	s.	d.	%
Manual Labour	13	6	8	1	5	6	37.2
Horse Labour	3	9	3	0	6	8	9.6
Tractor	0	2	11	0	0	3	0.4
Fertilisers	2	11	4	0	4	10	7.2
Farmyard Manure	4	1	7	0	7	10	11.4
Seeds	0	8	5	0	0	10	1.2
Rent and Rates	2	5	6	0	4	4	6.3
Establishment	3	4	6	0	6	2	9.0
Other Expenses	0	12	9	0	1	3	1.8
Carriage	5	14	5	0	10	11	15.9
Gross Cost	35	17	4	3	8	7	100.0
Deduct Value of Manurial Residues ..	3	6	11	0	6	5	
Net Cost	32	10	5	3	2	2	

£33 2s. 5d. in 1929. The average yield over the period was 10½ tons of washed beet per acre. Although yields were above normal in each of the three years, only in the first year did the receipts from the crop cover the net cost. The profit shown in that year was £5 11s. 3d. over two acres. Over the series of three years there was a total loss of £17 10s. 6d., or £2 3s. 10d. per acre. It is not suggested that this is an exact measure, as such factors as value of tops and value of the crop for cleaning purposes should be considered, but obviously no exact cash value can be given to either.

Hay and Pasture costs.

Another difficulty arises in arriving at cost of production of hay. Aftermath is a valuable by-product of the hay crop and it would be obviously unfair to charge the whole cost of the overhead charges to a crop which only occupies the land six months or slightly more of the year. The orthodox practice is to allow one-third of costs other than labour to cover aftermath and to be charged to the pasture account, and this was followed. The charge for grass seeds purchased yearly was divided equally between pasture and hay.

The yield of hay was 32 cwt. in 1927, 24 cwt. in 1928, and 22 cwt. in 1929. Cost per ton of hay varied according to yield, although cost per acre remained fairly constant throughout.

Cost of hay and pasture—average of three years.

	Hay Per Acre.	*Hay Per Ton.*	*Pasture Per Acre.*
Total Acreage (three years) ...	117.2	—	230
	£ s. d.	£ s. d.	£ s. d.
Manual Labour	0 18 11	0 14 6	0 3 4
Horse Labour	0 3 9	0 2 11	0 0 6
Fertilisers	0 10 11	0 8 5	0 2 4
Farm Yard Manure	0 10 2	0 7 9	0 16 6
Seeds	0 6 0	0 4 8	0 2 6
Rent and Rates	2 5 8	1 15 0	2 4 9
Establishment	0 4 3	0 3 3	0 0 10
Sundries	0 3 6	0 2 8	0 11 11
Gross Cost	5 3 2	3 19 2	4 2 8
Credits for Aftermath and Manurial Residues...	1 9 6*	1 2 7	0 3 4†
Net Cost	3 13 8	2 16 7	3 19 4

* Cost of Aftermath. † Credit for Manurial Residues only.

Summary of Profits and Losses.

Over a series of years the net profits or losses over the farm as shown by cost accounts are approximately the same as shown by simple financial records. The claim made for cost accounts is that they show, in addition to the result in total, the profits or losses as estimated to have been the result of each enterprise. With a complicated farming system combining together many inter-dependent enterprises, in both crops and stock, this test cannot be applied rigorously. The arbitrary character of many allocations of overhead and other charges has been pointed out above and all that can be claimed for the summaries of profits is that they provide a rough indication of profitability or otherwise of each enterprise. It cannot be claimed that the profits attributed to any enterprise are in any way an *exact* measure of profits earned therein.

The total profit shown over the three years in the farm accounts was £600 17s. 8d., an average of £200 5s. 10d. each year. The two principal enterprises on the farm, dairy cattle (with other cattle) and sheep, showed net losses over the period, while pigs (on the stated bases of charges for whey) produced more than half the total net profit. The other enterprises contributing to net profit were potatoes (part of this profit was made by trading transactions), poultry, straw, hay, and contract work.

Summary of Losses over three years.

	1927.			1928.			1929.			*Total.*		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Other Cattle	115	0	9	71	10	10	49	8	5	236	0	0
Pigs	3	15	10		—			—		3	15	10
Sheep		—		48	19	11	74	19	8	123	19	7
Sugar Beet		—		3	14	5	19	7	4	23	1	9
Contract Work ...		—			—		5	6	3	5	6	3
Dairy Cows		—			—		112	4	11	112	4	11
Total	118	16	7	124	5	2	261	6	7	504	8	4

Summary of Profits over three years.

	1927.			1928.			1929.			*Total.*		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Dairy Cows	126	8	1	99	14	9		—		226	2	10
Sheep	21	0	5		—			—		21	0	5
Poultry	27	1	5	27	13	8	15	18	8	70	13	9
Oats	49	4	6	17	6	8	20	3	9	86	14	11
Potatoes	48	19	4	107	1	1	45	14	0	201	14	5
Sugar Beet	5	11	3		—			—		5	11	3
Straw	4	12	8	14	17	7	33	14	5	53	4	8
Contract Work ..	24	1	7	9	10	11		—		33	12	6
Pigs		—		91	6	10	270	17	0	362	3	10
Hay		—		33	7	10	3	17	8	37	5	6
Mixed Corn		—			—		3	9	6	3	9	6
Wheat		—			—		3	12	5	3	12	5
Total	306	19	3	400	19	4	397	7	5	1,105	6	0

The total net profit over both the ownership and occupation enterprise was only £824 18s. While the average profit on the farm over the three years was £200 5s. 10d., the total earnings of the family (including value of family labour recorded in expenses) is £469 1s. 4d.; or taking only the value of labour of the farmer himself as income and treating the recorded value of labour of other members of family as actual expense the average income of the farmer is £275 1s. 10d., less loss of £92 on estate.

On this farm, yields of crops have been good practically throughout the period. The standard of technical management is higher than normal. The small profits are partly to be accounted for by the necessarily high rental charge on the farm. Had rental charges remained at the level of 1920 much better results would be shown: in fact, such results as might be regarded as satisfactory in a period of falling prices. In effect, expectations of earning powers of this farm held in 1920, and

expressed in capital values, have not been realised. The soundness of the investment in the farm cannot yet be judged; it awaits determination in the future movements of prices of land and produce, but judged from temporary farming conditions the ownership enterprise was much overcapitalised in 1920.

SEASONAL DISTRIBUTION OF MANUAL AND HORSE LABOUR ON WELSH FARMS.

By J. Llefelys Davies, M.Sc.,
University College, Aberystwyth.

An investigation into organisation and use of labour power on mixed farms in Wales commenced in May, 1925, and continued until December, 1927, produced a great mass of empirical information in relation to the amount and distribution of manual and horse labour. Some sections of the data have been published,[1] but mainly material showing quantitative requirements of crops and stock. The investigation was conducted by means of daily time sheets, on which the farmers or their employees recorded time spent on each task by every person engaged in farm work. Analysis of this information for each farm gave a complete picture of the distribution of labour over the different enterprises within the general farm business, and the labour requirements per unit for each task. Of equal importance was the picture obtained of the utilisation of labour at different seasons of the year, showing how each enterprise had its peculiar seasonal demand curve and how all the demands were fitted together to coincide with the work capacity of a fairly steady supply. Both manual and horse labour are important items in farm expenses and their distribution with judgment and discretion, having regard to the requirements of the various tasks and the probable productivity of alternatives, constitutes one of the most intricate problems in farm management. The goal of efficiency is always aimed at in management of labour, and investigations into labour organisation on farms are expected to point the way. Even from the point of view of the farm manager, efficiency is not easy to define. It may be indicated by various tests (*a*) output, quantity, or cash, per person employed, (*b*) return in cash per hour of labour utilised, (*c*) output in cash per unit of labour cost, (*d*) total task per unit of available labour. But neither of these formulae can be used to compare efficiency in labour accomplishment from farm to farm, except on farms where the same system is followed and natural

[1] See "Economic Conditions in Welsh Agriculture", A. W. Ashby. Appendix by J. Llefelys Davies. *Farm and Market*, No. 3 and No. 4.

conditions of soil, climate, topography, are closely similar. Again, labour cannot be dissociated and treated apart from the other factors of production. Some farmers invest in machinery to undertake work which is done by manual labour on other farms. While it is economical on some Welsh farms to use tractors or potato lifters and sorters, on others to use horse-drawn ploughs and to lift potatoes by hand is good economy having regard to possible alternative use of available horse and man labour. Efficiency in labour management can only be judged for each farm individually, taking into account the farming system, size and layout of the farm and the extent and the distribution of the demand for labour.

There are two principal factors in the economy of manual labour on the farm. The first refers to the amount of time and therefore to the cost of labour required for a given task. This is a question of good management of labour on the part of the farmer, who provides the equipment and tractive power, the nature of which can influence so much the output of work, and a question of honest and conscientious workmanship on the part of the worker. The second relates to the arrangement of enterprises (crops and stock) fitting together those which demand labour at different seasons of the year, and providing the available labour supply, both of men and horses, with productive tasks without periods of undue slackness or excessive intensity throughout the year. It is desirable that productive work should be as regular as possible throughout the year. But this is difficult to achieve, especially on mixed farms, where climatic conditions may upset forward-looking arrangements, although farmers can endeavour to arrive at the most economical distribution within the limits set by natural conditions. In some cases this would entail modifications in the farming system or some curtailment or increase in the labour supply or possibly both. The composition of the farming system and the supply of labour are mutually dependent.

The details of the distribution of labour on sixteen Welsh farms are set out below in an attempt to illustrate this aspect of the complexity of farm labour management. The farms were situated in the counties of Caernarvon, Merioneth, and Cardigan, and the analysis covers a period of approximately two and a half farming years.

All the farms were principally concerned with the production of livestock and livestock products. Two of the farms sold liquid milk, while butter was made on the others. On all except three farms, cattle breeding and rearing was the main enterprise.

The exceptions were three highland sheep farms, but their system included all classes of livestock although sheep predominated.

The average size of the group was 145 acres, with a range from the smallest farm of 48 acres to the largest with 820 acres of land. In calculating acreage, rough grazing land, which formed a large proportion of the total acreage on the highland farms, was reduced to one-fifth in an endeavour to obtain a comparable acreage basis. It is possible that in order to secure a sample fully representative of farms in Wales, the group should contain a greater number of small farms, but the smaller the farm, the more difficult it is to study labour distribution. Many of the small farms are worked by the family; there is hardly any division of labour function and each member may do several different tasks in the course of each day. Under such conditions it becomes practically impossible to record movements accurately on labour time sheets. On many small farms, work on the holding does not give full employment and work outside the farm is often sought. But the problem of distribution of labour exists for the small as well as for the bigger farm, although it is more difficult to examine and study.

Functional distribution of manual labour time.

In calculating the amount of manual labour time spent on each task, the time of hired and family workers (both male and female) was included as well as actual time spent on specific tasks by farmer or manager. Time was expressed in all cases as hours of man labour, no distinction being drawn between male and female time or between time put in by different classes of workers, although obviously an hour of labour is no fixed standard and its value varies with each person, although its cost may be fairly constant. Work done by horses was also recorded in horse hours irrespective of the nature of the work done. The average distribution of manual and horse labour time over the principal farm enterprises for two complete years was as follows :

	Manual labour. %	*Horse labour.* %
Total livestock (attendance on all classes of stock)	48.7	3.2
Cereals	11.3	37.0
Roots and potatoes	14.1	33.5
Pasture and hay	7.7	13.9
Total land	33.1	84.4
Establishment	14.2	6.9
Exchange labour	2.1	3.8
Domestic	1.7	1.5
Contract work	0.2	0.2
Total	100.0	100.0

The exchange labour in the Table above is that given to other farms. The exchange labour received is included with that of the usual staffs of the farms, casuals, etc., in the other items shown for crops, etc.

Distribution varied for each individual farm, according to the balancing of enterprises within the farming system and according to the policy of the farmer in regard to the needs of the different enterprises. Some farmers gave intensive attention to livestock, or some branch of livestock, while others were more concerned with the general appearance of the farm and devoted a large proportion of labour time on " establishment " or in cultivation and harvesting of arable crops. The range between individual farms for " livestock " manual labour was from 84 per cent. to 60 per cent. of total labour time, with " land " labour from 24 per cent. to 44 per cent., and with " establishment " labour from 4 per cent. to 22 per cent. Exchange labour, or labour time spent in helping neighbouring farmers at stress periods, amounted to 6.7 of total time on one farm, as compared with the average for the group of 2.1 per cent., while on one holding this item did not occur at all. With horse labour time, the distribution was more straightforward, the greater proportion, equal to 84.4 per cent. on the average of the group was spent on land work, cultivating and harvesting arable and grass crops. The range for individual farms was from 73 per cent. to 99 per cent. total labour given to land. For " establishment " work there was a range from 7 per cent. to 11.8 per cent. of total time. All the farms except three utilised some horse labour time in " exchange " work helping neighbours, one farm showing 11 per cent. of horse time thus spent. Horse work on livestock only formed 3.2 per cent. of total time over the group, with variations from 0.4 per cent. on the smallest farm to 11.0 per cent. on one other.

Seasonal distribution of labour.

Livestock.

Much of the work of attendance on livestock on Welsh mixed farms is done by women. They may be members of the household, like the farmer's wife, or daughters, or hired servants partly employed in the house and partly engaged in farm duties. There was a time when it was customary for the women to work on the land at all stress periods, but the introduction of machinery, and laying of much arable land to grass, has caused the peak demands for labour to be less marked, and more nearly within the labour capacity of the regular male staff without much

additional help from the farm women or even of casuals. But on many farms, especially those worked mainly by the family, the rearing of calves, milking, butter-making, and in some cases feeding of dairy cows, are still undertaken by the women, who usually have complete charge of the poultry and sometimes of pig enterprises.

Diagrams 1-5 demonstrate the seasonal demand for manual labour by each of the livestock enterprises. The sample covers thirty-two farming years (sixteen farms, two years each) and the data is set out on a monthly basis. Unfortunately the calendar months contain varying numbers of days, and to allow for this the year has been divided into eight months of four weeks each, with the four months, March, July, September, and December, as each containing five weeks. To obviate the necessity of including columns of unequal width in the diagrams, all the calculations have been made on a weekly basis, and the total

DIAGRAM 1.
Monthly distribution of manual labour on horses.

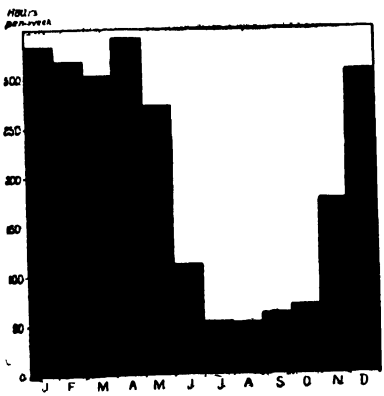


DIAGRAM 2.
Monthly distribution of manual labour on cattle and dairy.

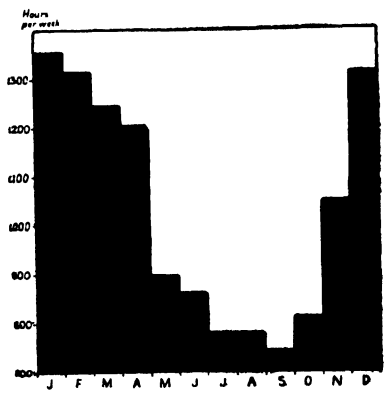


DIAGRAM 3.
Monthly distribution of manual labour on sheep.

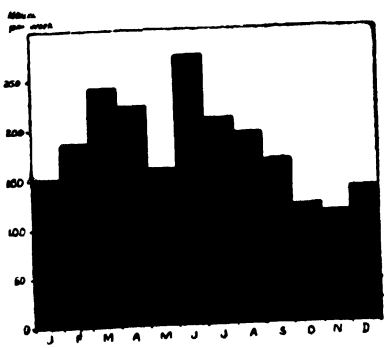


DIAGRAM 4.
Monthly distribution of manual labour on pigs.

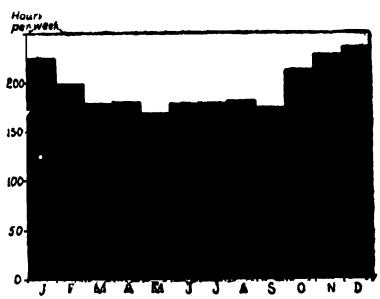
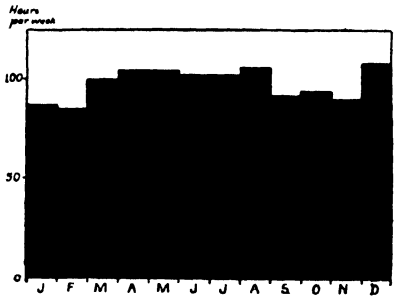


DIAGRAM 5.
Monthly distribution of manual labour on poultry.



hours for the month can be arrived at by multiplying the weekly total by four or five as the case may be.

Horses.

There are two methods of treating manual labour on horses in such investigations as this : (*a*) to treat horses, working and other, as one branch of farm stock, and put all attendance labour to the " horse account ", (*b*) to treat attendance labour on working horses as labour for the crops and stock, etc., to which the actual horse-labour is given. The former method is adopted here, because of the high amounts of attendance labour on horses when comparatively little horse-labour is being done on crops, etc. Attendance labour on all horses, working and other, is included.

Diagram 1 shows the extreme seasonality of work in attendance on horses. From June to October the animals are usually out on grass and they only require attention in cleaning and feeding on actual working days. During the winter and spring months when they are indoors their requirements of labour are fairly regular, but showing a slight increase in April, the month of peak demand for horse labour.

Cattle.

The distribution for cattle (including dairy and other cattle) is very similar to that for horses, except that the April peak is absent and that the month of May shows a low requirement. On all these farms cattle were mainly wintered indoors from about the middle of November to the beginning of May. The labour on cattle in the summer months was mainly in milking and butter-making, or milk delivery with the dairy cows, and calf rearing with the other cattle.

Sheep.

There are two peak periods, one in March and April at lambing time, and the other in June at shearing time. Preparation for lambing and lambing extends from February to April, varying in time on individual farms. Most of the shearing on these farms was done in June, but dipping, marketing, etc., extend to September. Practically all the sheep on these farms were kept on grass, with only occasionally instances of lambs being fattened on roots or fodder crops during the winter. In these cases there was no elaborate folding on the crops.

Pigs and poultry.

Labour of attendance on these enterprises was in the main undertaken by women, and the demand was remarkably regular. Slightly increased hours are required by pigs in winter, when more feeding for bacon and pork is usually undertaken. The December peak with poultry is almost wholly due to preparation of table poultry for market at that time. The more extended demand by poultry occurred from March to August, when most of the rearing was done.

Total of work by women.

The total amount of work done by the women on crops and stock, but mainly on the latter, was fairly constant over the year. This included practically the whole of the work on pigs and poultry, with a proportion of the work of attendance on dairy cows, covering mainly calf-rearing, milking, and butter-making. The number of hours worked per week by women on these farms was as follows :—

	Hours.	%		*Hours.*	%
January	450	5.0	July	493	5.4
February	441	4.8	August	496	5.3
March	465	5.1	September	489	5.3
April	496	5.4	October	480	5.3
May	463	5.1	November	450	5.0
June	503	5.5	December	442	4.8

Crops.

In diagrams 6 and 7 the average distribution of all labour for two complete years is shown for all cereal crops and all root crops, including potatoes. In arranging work on crops, the farmer has to consider horse as well as manual labour and the supply of either may set a limit to the amount of task to be undertaken in any given amount of time. Tractors were utilised for cultivation on two of these farms, but the amount of tractor work done showed that it was only used on occasions to supplement horse labour at the busy seasons.

DIAGRAM 6.

Monthly distribution of manual, horse and tractor labour on Cereal crops

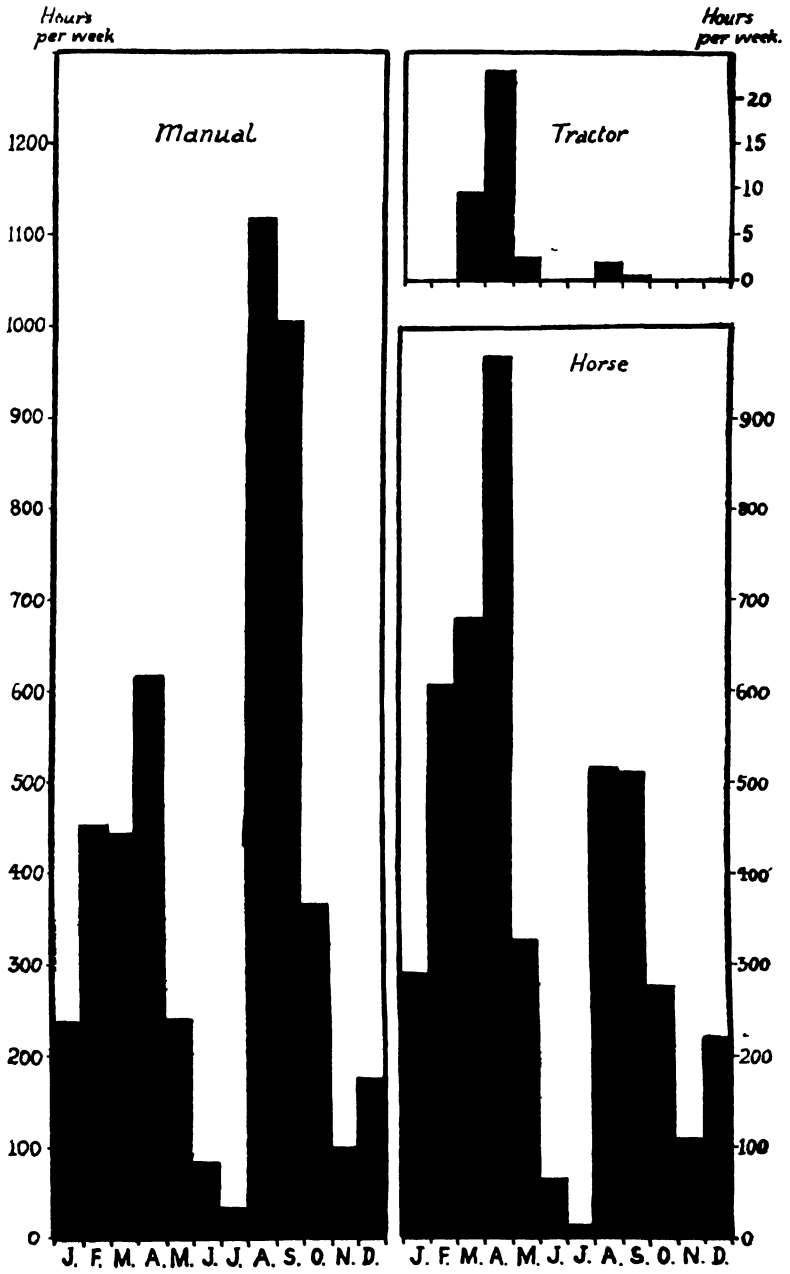
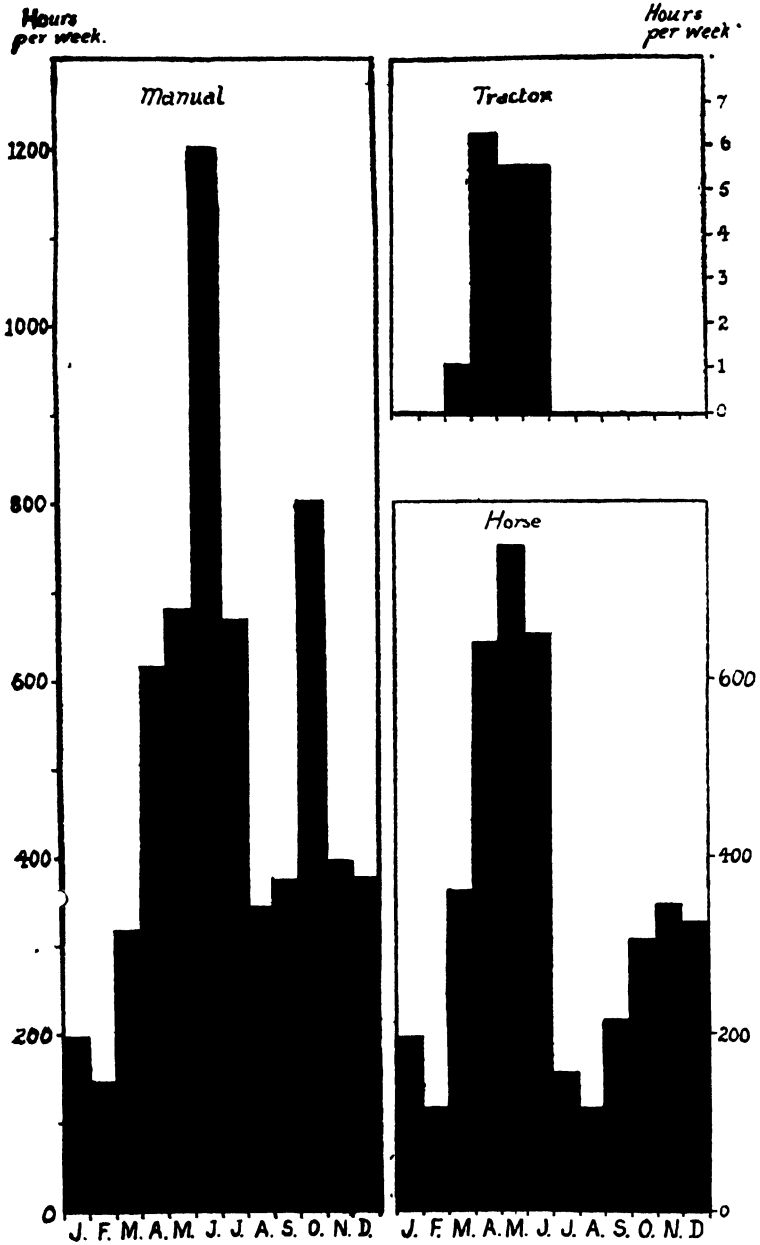


DIAGRAM 7.
Monthly distribution of manual, horse, and tractor labour on Root crops.



The distribution of the work with cereals shows two main peak periods of demand for labour. The first in March and April at planting time, when the peak demand for horse with

tractor labour is much steeper than the demand for manual labour, and the second in August and September, which only affects horse labour slightly but creates a steep peak demand for manual labour at harvesting. The work on cereals in the winter and early spring months consists mainly of preliminary ploughing, which affects both horses and men, and some threshing, which increases the demand for manual labour.

With roots and potatoes, the distribution of work is even more irregular than with cereals. Two high peaks occur with manual labour, the first in June for ploughing, manuring, and for hoeing of roots, and the second in October, for potato lifting. The peak for horse labour occurs in May, at planting time for roots, and this coincides with a very low demand from cereals. In April the demand for horse labour is intense, both by cereals and roots; by the latter mainly on account of potato planting. The demand for horse labour from potatoes is comparatively low in autumn at lifting time and about equal to manual labour in November and December, when mangolds and swedes are lifted.

Diagrams 8 to 14 show seasonal distribution of manual and horse labour for individual crops. These have been calculated on the basis of complete cropping years. The work on an individual crop does not begin and end within a complete calendar year, and in some cases work extends over a period of eighteen months or more. In this study work on individual crops was followed from the first ploughing of the land to the final disposal of the produce and the cycle of work is presented in these diagrams on a monthly percentage basis. Work time was recorded daily and the analysis made on the basis of a calendar month. The diagrams represent results of two complete crop cycles.

DIAGRAM 8.

Percentage monthly distribution of manual and horse labour on Oats.

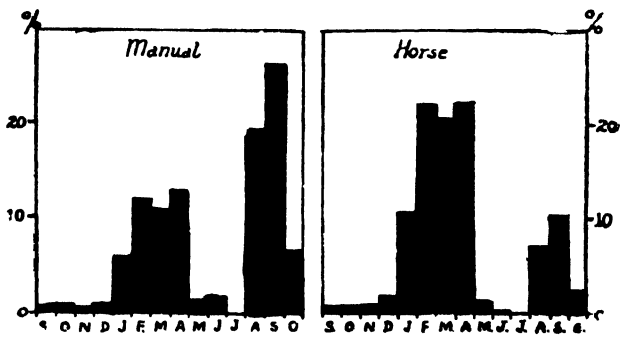


DIAGRAM 9.

Percentage monthly distribution of manual and horse labour on Wheat.

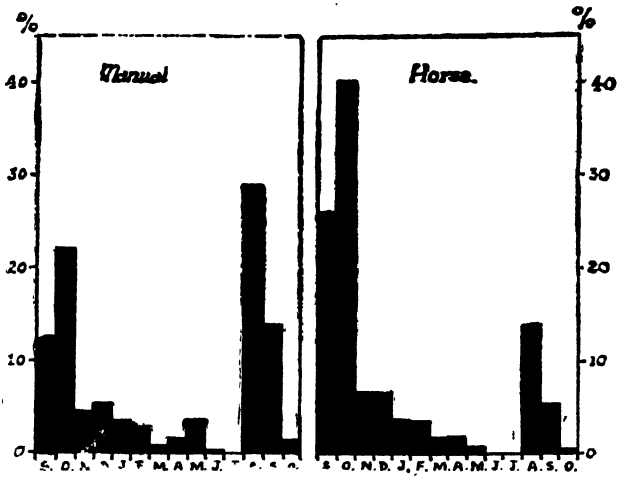


DIAGRAM 10.

Percentage monthly distribution of manual and horse labour on Swedes.

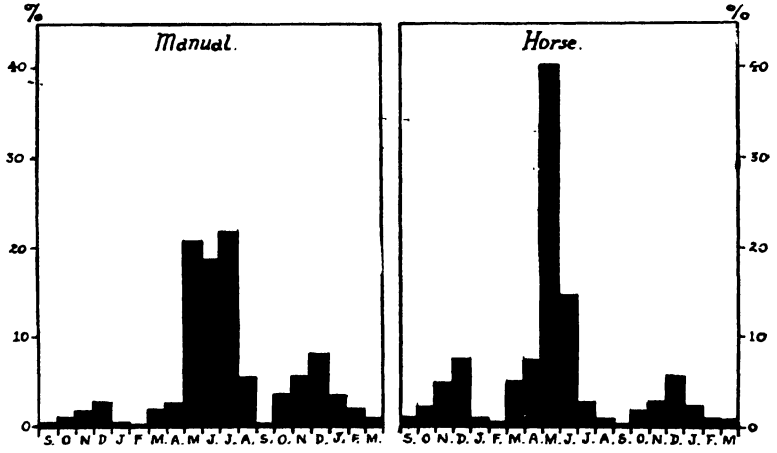


DIAGRAM 11.

Percentage monthly distribution of manual and horse labour on Potatoes.

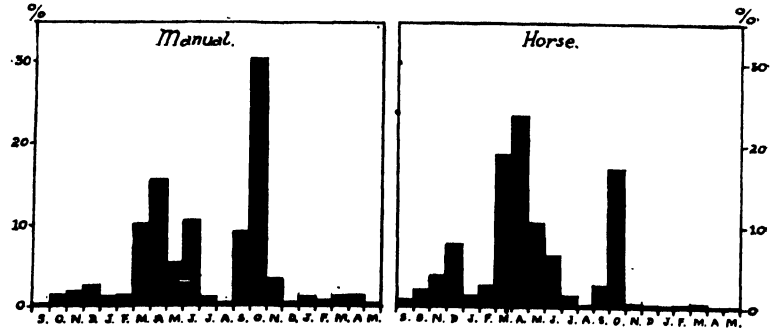


DIAGRAM 12.

Percentage monthly distribution of manual and horse labour on Mangolds.

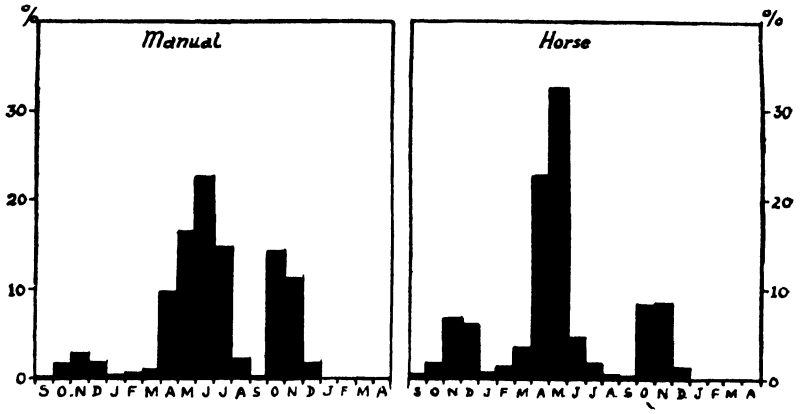
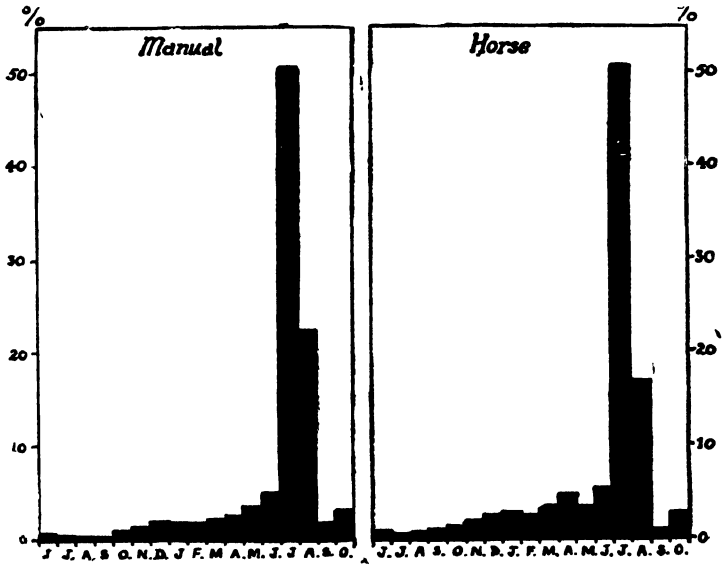


DIAGRAM 13.

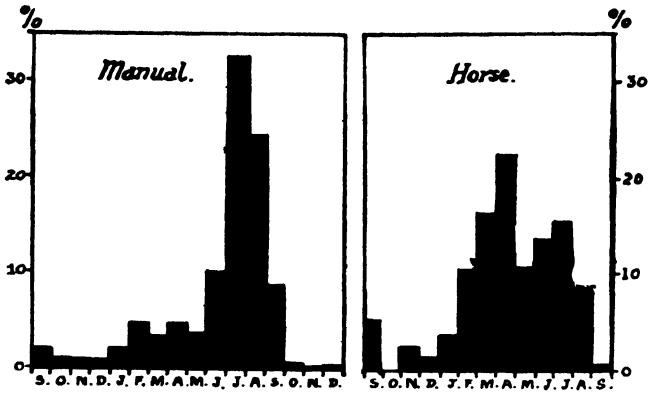
Percentage monthly distribution of manual and horse labour on Hay.



With the cereal crops, the complete crop-year on the average extended over about thirteen months, but this relatively short work-cycle for these crops was the result of conditions on these farms. Relatively little threshing was done, for most of the oat crops were chaffed for stock, and manual labour on chaffing is put to the appropriate livestock account. Sometimes threshing and chaffing was done at the same time and with the same power. Threshing, especially for seed, sometimes extends to March or

DIAGRAM 14.

Percentage monthly distribution of manual and horse labour on Pasture.



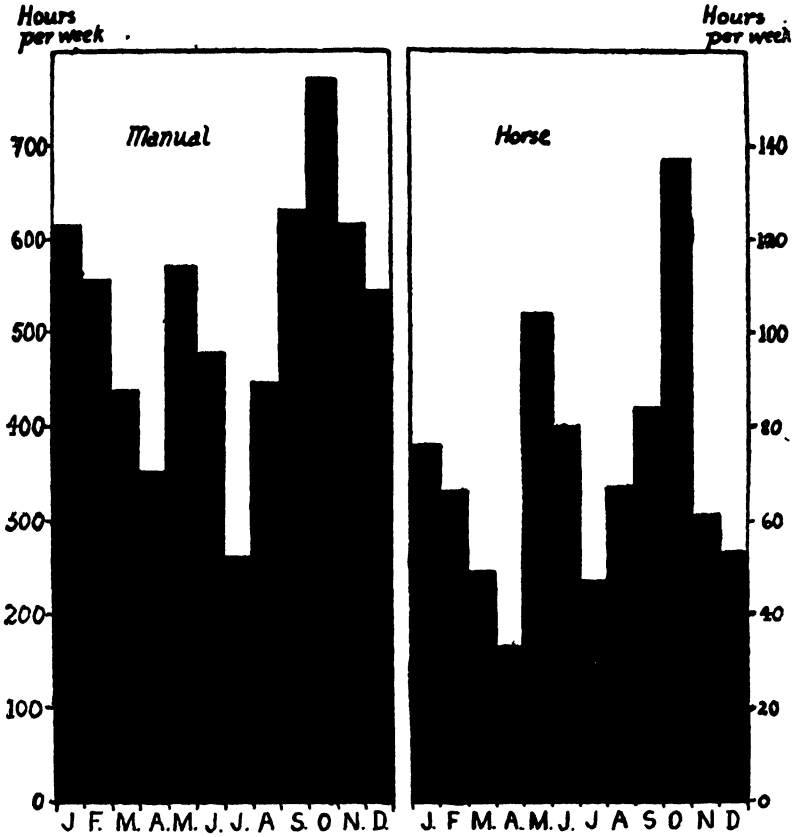
April following the harvest concerned. The average period of thirteen months represented processes from the first ploughing in September to stacking, thatching and a little threshing in October. Only winter wheat was grown on these farms, and the peak demands for labour occurred in October for planting and in August and September for harvesting. Work on oats, which is a crop of greater importance on Welsh farms, was intensive for each of the spring months, when most of the ploughing, cultivating, and planting operations were done. Distribution of labour on root crops and potatoes was spread over a very long period, partly because farms differed in the methods adopted for harvesting and utilisation of these crops. In some cases swedes were left in the ground to be carried as required throughout February and on to March. Work on potatoes from November to May consisted mainly of sorting in preparation for the market. Labour on the hay was spread over a period of more than a year, although demand was only intense at harvesting in June and July. Other work on hay consisted of manuring, harrowing, and thatching. The principal operations on pasture were manuring, carried out at all seasons when opportunity occurred, and thistle cutting and general cleaning of surplus grass in July and August.

Distribution of establishment and exchange labour.

Diagram 15 shows the seasonal variation in labour applied to general farm tasks. The distribution follows the same trend for both man and horse labour, with the exception of some of the winter months, when the general work consisted largely of indoor work on wet days. In amount it is quite naturally least at the two main stress periods of crop cultivation and planting

DIAGRAM 15.

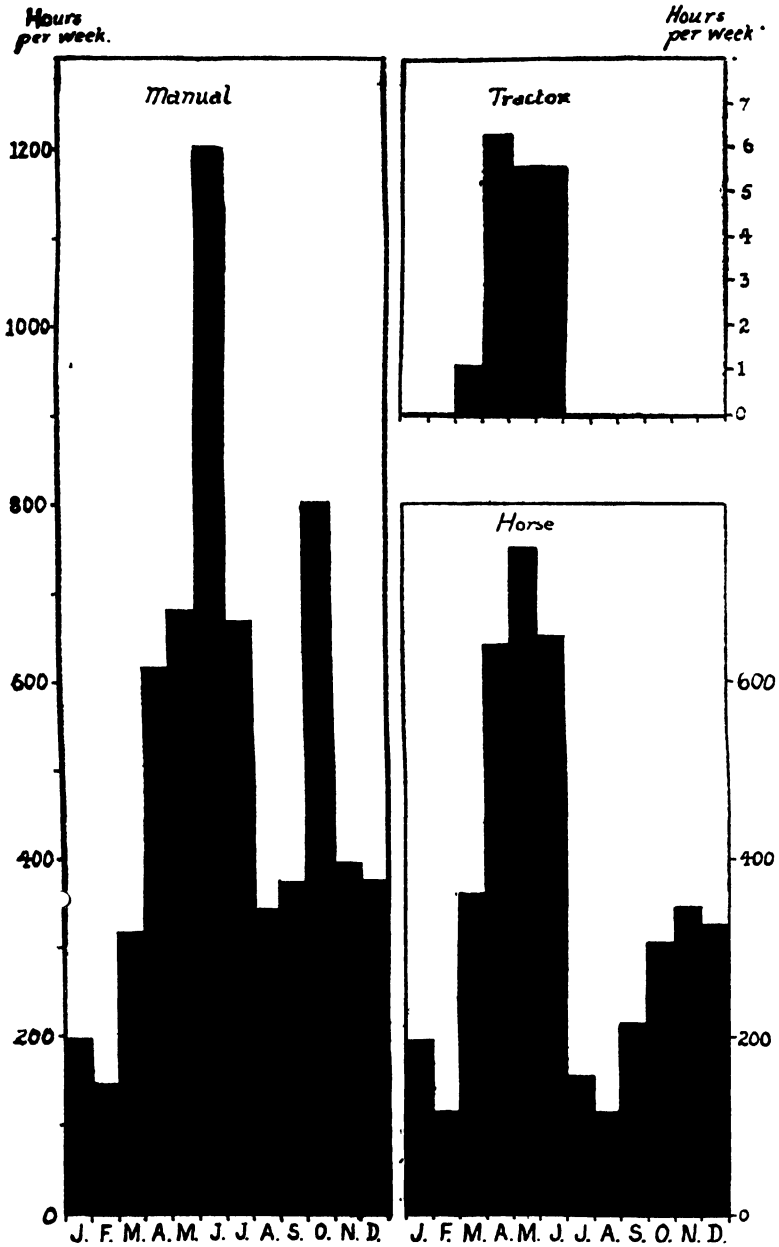
Monthly distribution of manual and horse labour on Establishment.



in April and hay harvesting in July, and greatest in October, with September and November following closely. Extensive work with hedges is often done in October or thereabouts. No general distribution can be laid down for work of this character. Much depends on weather conditions and a wet October might show a high proportion of establishment labour and November a low one, if the latter month is sufficiently dry to allow some of the normal October tasks to be undertaken.

The amount of exchange labour in relation to the total is comparatively small (see page 65), but has an importance which is out of all proportion to its amount. Diagram 16 shows its incidence to coincide with two principal stress periods at hay and potato harvest. On many farms this practice of exchanging labour is being discontinued and the need for it is being reduced by the introduction of more machinery for harvesting purposes.

DIAGRAM 7.
Monthly distribution of manual, horse, and tractor labour on Root crops.



The distribution of the work with cereals shows two main peak periods of demand for labour. The first in March and April at planting time, when the peak demand for horse with

tractor labour is much steeper than the demand for manual labour, and the second in August and September, which only affects horse labour slightly but creates a steep peak demand for manual labour at harvesting. The work on cereals in the winter and early spring months consists mainly of preliminary ploughing, which affects both horses and men, and some threshing, which increases the demand for manual labour.

With roots and potatoes, the distribution of work is even more irregular than with cereals. Two high peaks occur with manual labour, the first in June for ploughing, manuring, and for hoeing of roots, and the second in October, for potato lifting. The peak for horse labour occurs in May, at planting time for roots, and this coincides with a very low demand from cereals. In April the demand for horse labour is intense, both by cereals and roots; by the latter mainly on account of potato planting. The demand for horse labour from potatoes is comparatively low in autumn at lifting time and about equal to manual labour in November and December, when mangolds and swedes are lifted.

Diagrams 8 to 14 show seasonal distribution of manual and horse labour for individual crops. These have been calculated on the basis of complete cropping years. The work on an individual crop does not begin and end within a complete calendar year, and in some cases work extends over a period of eighteen months or more. In this study work on individual crops was followed from the first ploughing of the land to the final disposal of the produce and the cycle of work is presented in these diagrams on a monthly percentage basis. Work time was recorded daily and the analysis made on the basis of a calendar month. The diagrams represent results of two complete crop cycles.

DIAGRAM 8.

Percentage monthly distribution of manual and horse labour on Oats.

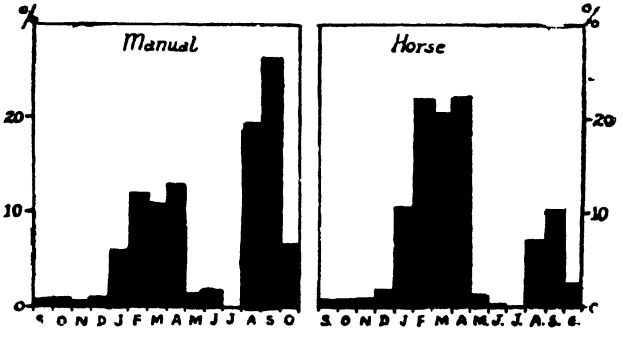


DIAGRAM 9.
Percentage monthly distribution of manual and horse labour on Wheat.

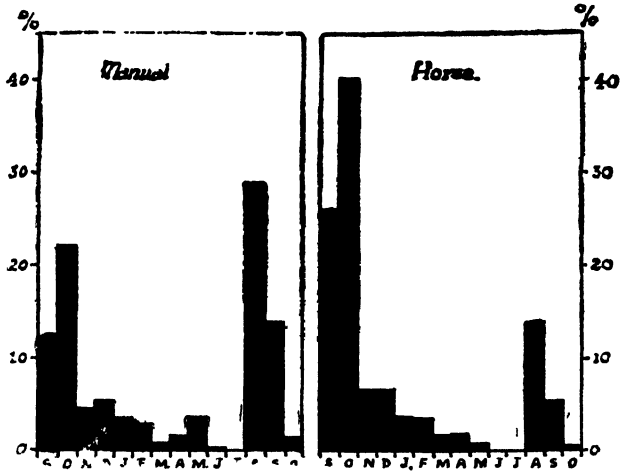


DIAGRAM 10.
Percentage monthly distribution of manual and horse labour on Swedes.

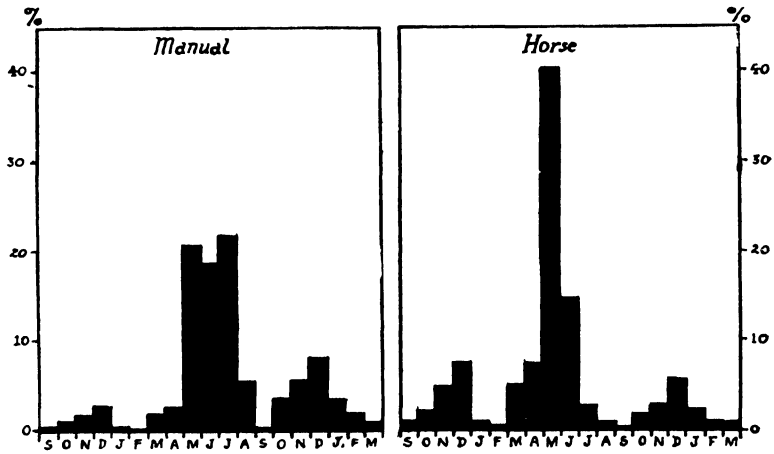


DIAGRAM 11.
Percentage monthly distribution of manual and horse labour on Potatoes.

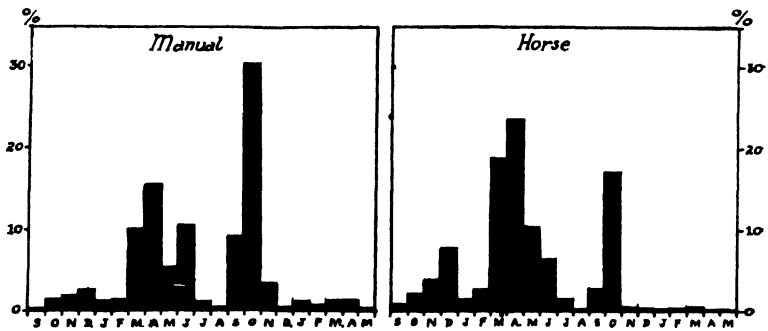


DIAGRAM 12.

Percentage monthly distribution of manual and horse labour on Mangolds.

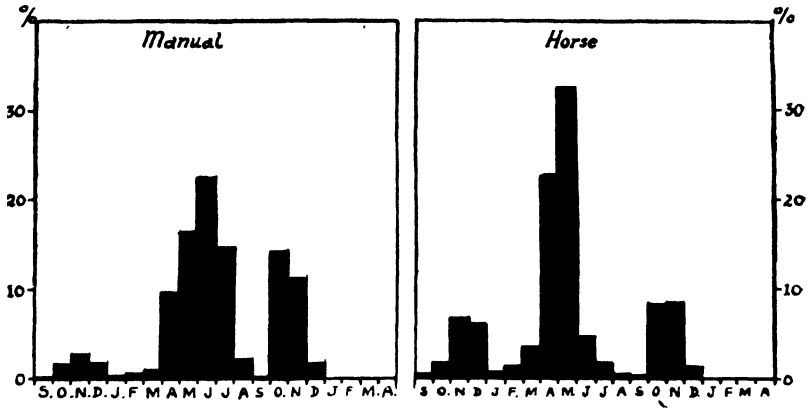
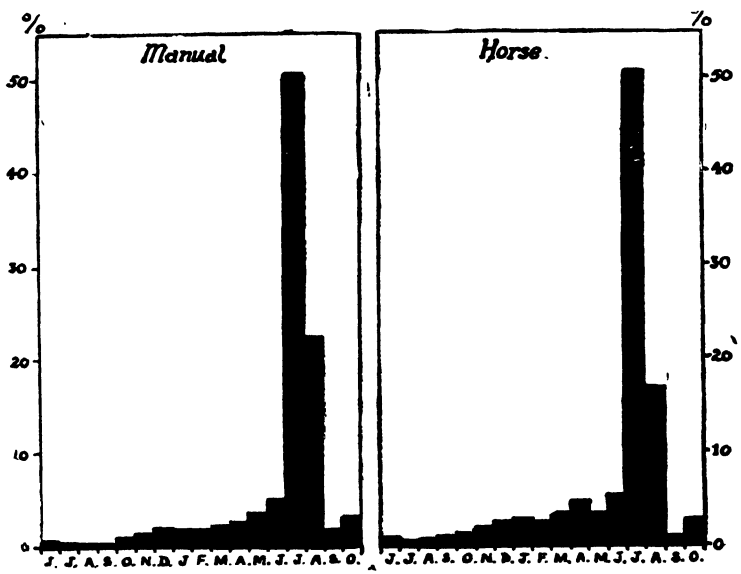


DIAGRAM 13.

Percentage monthly distribution of manual and horse labour on Hay.



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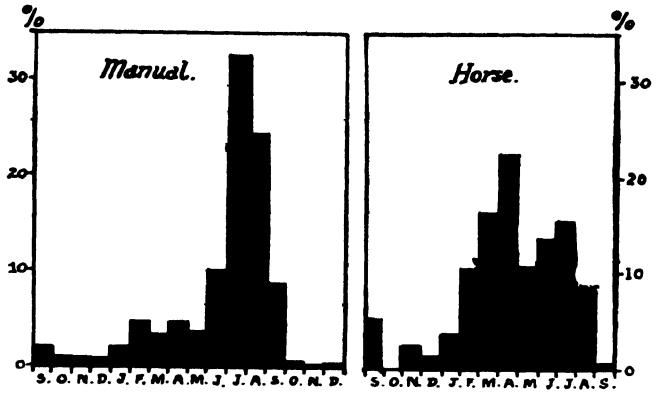

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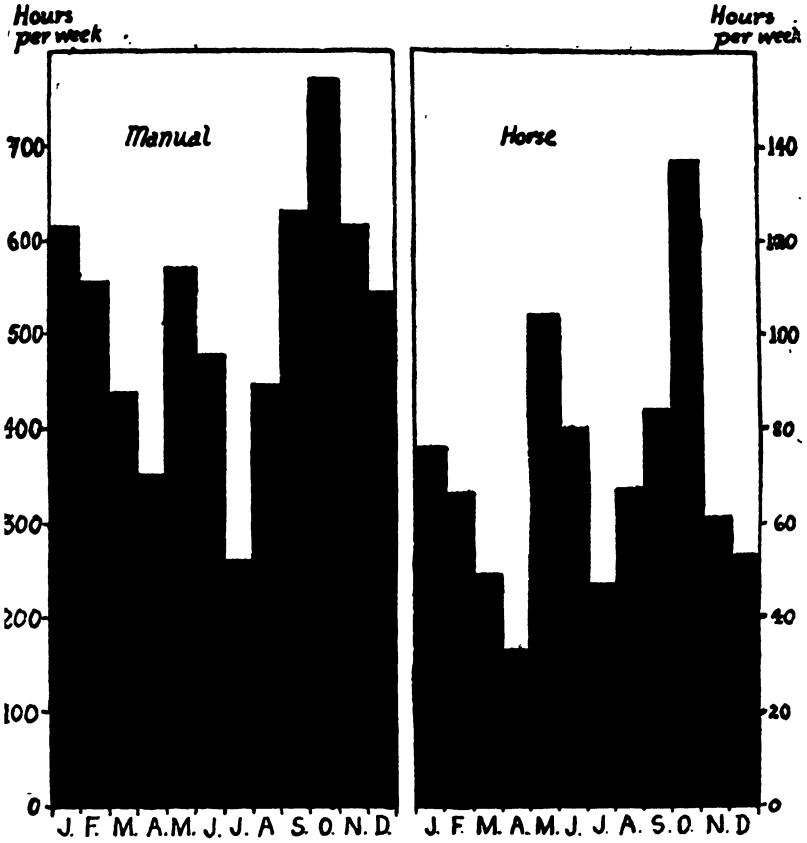

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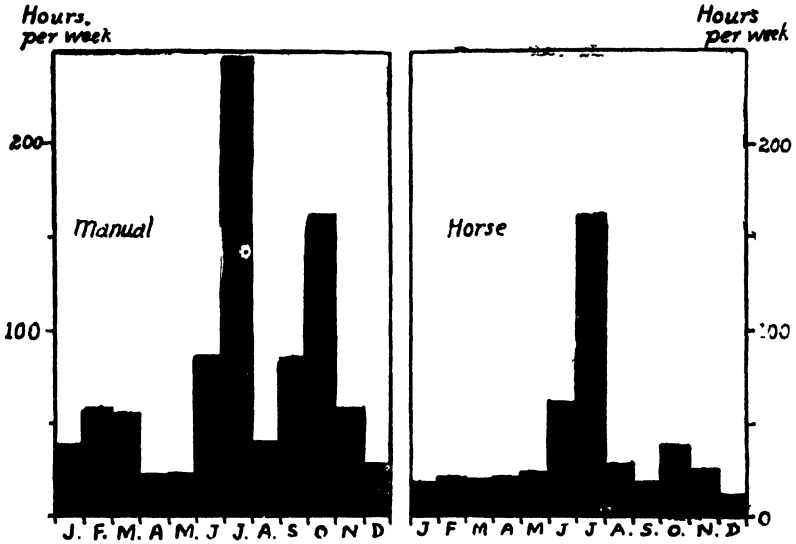
DIAGRAM 16.

Monthly distribution of manual and horse exchange labour given.



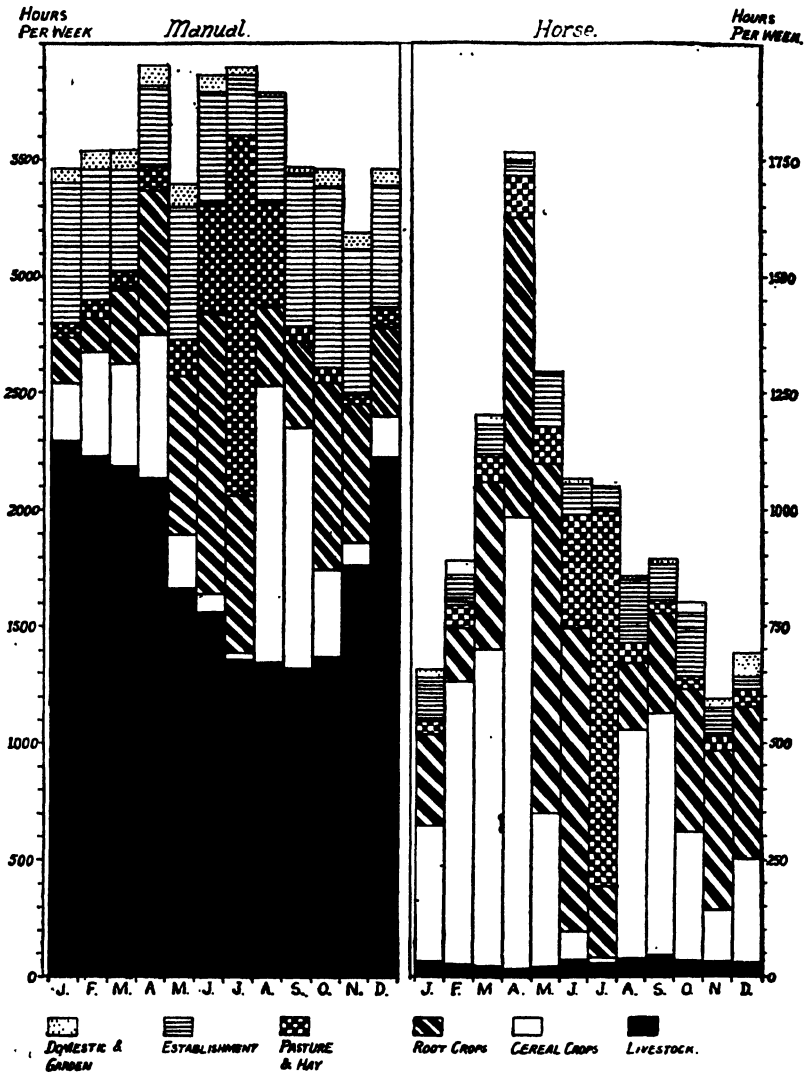
but it will still be necessary on small farms at the busy periods, because it is only by some co-operative effort that harvesting can be done in the time available without the aid of expensive machinery.

Distribution of total labour.

The fitting together of all the demands for labour is clearly demonstrated in Diagram 17. Only the main divisions of enterprises are shown, and within each division the component enterprises offer the same problem to the farm manager. In the diagram, manual labour on livestock takes a prominent place, but varying somewhat in the demands made during summer and winter. But this total livestock requirement is made up of the individual requirements of the several classes of livestock, which as shown above fluctuate according to season, each having a peculiar demand curve. Similarly with crops; but broadly speaking, the cereals demand most labour in the spring and autumn months, while roots and potatoes show peak demands in summer and late autumn. The hay crop is perhaps more definitely seasonal than any, showing intensive demand for labour in July, with lesser demands in June and August. Establishment work equalises the demand for direct labour at all times. A little of this work may be included to create occupation for slack periods, but far the greater part is work on fences, ditches, roads, etc., which is necessary and eventually productive. But

DIAGRAM 17.

Total monthly distribution of manual and horse labour.



one of the problems of labour management is that of using the available work force on productive work throughout the year and to obviate the necessity of any mere time-filling work to fill in gaps.

The total amount of manual labour utilised is shown by the diagram to have been remarkably regular each month. The months of stress as measured by numbers of hours worked were April, June, July, and August, while the slack months were

November and May, two months in which wage contracts are normally completed and there follows some disorganisation when workmen take holidays.

In contrast, the total amount of work done by horses in each month is shown to have been extremely variable. April was the month with the highest requirement and the number of hours worked was more than three times the total for November. Under conditions on Welsh farms it would not be expected that horses could be kept working to full capacity in each month. Climate is an important limiting factor, and the farming system based largely on livestock does not offer opportunity for the best utilisation of horse labour. The number of horses maintained is decided by the demand at the periods of stress. The season when these occur varies to some extent from farm to farm, but on the majority of farms in this group it occurred in April, although in one or two cases there was evidence that it occurred during the hay harvest in July. It is a question for the farmer to decide whether horse labour can be organised for more economical use; but it is a complex problem, and other factors will have to be considered in approaching a solution. The supply of manual labour, the amount and kind of farm equipment, the nature and the component parts of the farming system, and the supply of horse labour, all are mutually dependent. Adjustment of any one of these is a delicate process, but adjustment is essential for the best results to be obtained in farm management.

LABOUR ASPECTS OF FARM LAYOUT IN WALES.

By J. Llefelys Davies, M.Sc.,
University College, Aberystwyth.

" The present arrangement of practically all farms is the result of accident. The older the country the worse the farm layout, because as new obstacles are introduced the fields become smaller and more irregular. As new buildings are built and old ones patched up, numerous unrelated buildings collect. Every farmer should make a more or less definite plan for the development of his farm, so that new fences and other changes will gradually work towards a definite plan ".[1]

The above passage refers to conditions in the United States where a great proportion of the farm land was laid out according to plan although in the districts where settlement first took place the same lack of uniformity occurs as in older countries. An

[1] G. F. Warren. " Farm Management ", 365.

endeavour to explain all the influences which have been effective in deciding the location of the farmstead and the peculiar layout of each farm in Wales would entail an elaborate study of Welsh rural history and an intensive study of local circumstances and conditions. Little information of this historical character is available even for individual districts and it would provide an interesting field of research for local organized effort.

The principal characteristic of the layouts of farms in Wales is their diversity. In some districts they were laid out according to a general basal plan which may be detected in all the farms although in individual cases this may have been altered from time to time.

An example of this is found in some hilly districts, where practically all the farms run in long strips up the slopes, each having a proportion of the better land at the lower elevations, with some middle land also enclosed as well as a proportion of hill or mountain contiguous with the other but in many districts unenclosed. The situation of the homestead varies only slightly from farm to farm according to special conditions such as shelter, water supply and drainage. But even on farms where the general plan is fairly uniform, within a district, the arrangement, shape, and size of fields vary from farm to farm as a result of certain considerations the nature of which often lie deep in history as well as in topography and the principles of natural drainage and farm use.

In other districts some farms, possibly the earlier ones, have been arranged according to a fairly uniform plan while others created later out of the remaining area, possibly uncleared at the time of earlier settlement, show traces of having been laid together piecemeal and fitted into whatever space remained. Yet in some districts, more recently enclosed, there are farms which are more uniform in size and layout, of which the size as well as the shape of fields is better suited to the type of farm than in districts where individual enclosed holdings had been gradually formed from earliest times. Much of the land that now belongs to the cultivated area of farms has been fenced piecemeal in quite recent times. A great deal of labour has been invested in the process and the shape of the fields shows that no clearly defined plan or method was set out and adhered to. On the contrary the present arrangement suggests that as much as possible was cleared in each year, and a boundary fixed when the strip was brought into cultivation. In many cases the boundary, temporary when first outlined, gradually became fixed and it still marks the shape and size of the field. In many parts of

Wales the field boundaries were built up of the stone cleared from the field, and the wide and apparently wasteful stone walls found enclosing fields were built not because they were considered necessary, but because they provided a cheap method of dealing with the material cleared from the land surface.

The contours of the land surface also had an important influence on layout of farms in Wales. The surface is broken by innumerable small streams and these often serve as boundaries between farms. Small hillocks and depressions occur everywhere while the valleys are frequently very narrow, so that sloping ground has nearly always to be included in the farm area.

Taking the two main influences together, first, the gradual fashioning of the holdings over centuries of time, and secondly, the many limits set on layout by physical conditions, it is possible to appreciate the variegated pattern presented by the layout of farms in Wales, and the even more diversified plan of field boundaries.

From the point of view of economy in working the layout of the farm is of great significance. There is for each farm an optimum situation for the homestead having relation to the layout of the fields, topography of the land, distance from the highway, convenience to water supplies, and with due attention given to shelter which is desirable for both man and beast. Again the layout or arrangement of the buildings in relation to each other and to the farm house has an important bearing on economy. In some cases the farm buildings are arranged neatly around a compact farmyard, and within easy distance of the rickyards, the whole arrangement making for the least possible waste of human effort in unnecessary journeys. In others the buildings are scattered, showing little evidence of a plan and resulting in unnecessary labour and inconvenience.

Another interesting feature of layout is the situation of the homestead in relation to the farm land. In many cases the fields are situated in a compact block surrounding the house and buildings while in others the homestead lies in a corner far away from the greater proportion of the fields. In cases of this nature much of the time of horses and men is wasted in travelling to and from work, and tasks such as manure hauling and carting of crops to the stackyard entail much labour and time that would be unnecessary if the fields were more conveniently situated. But the layouts of Welsh farms and the arrangement of buildings are likely to remain, subject only to slight modifications as for instance with the erection of new buildings or interchange of inconvenient fields by mutual agreement between farmers. The

shape of fields on the majority of farms leaves much room for improvement but when the boundaries are " hedges " (*i.e.*, banks with hedges on top) which are from six to eight feet high, and a few yards wide at the base, the task of removing them is too formidable to expect more than slight modifications in shape to be attempted.

The size as well as the shape of fields considerably affects the farm economy under arable conditions, although where the land is under grass small fields badly arranged do not impose quite the same handicap. In fact the recent tendency is to suggest that grass fields should be made smaller for better control and utilization of pasture. But on a large number of Welsh farms, although the proportion of arable land is small, it is rotated over a large number of fields, often during a course of years over the whole farm, so that many or most of the fields come under tillage at intervals.

General analysis of layout and size of fields.

Some of the variable factors in farm situation and lay-out in relation to labour requirements may be set out simply as below. Where indication of probable effect is given it must be read as " other things being equal," for the actual labour requirement is determined by a very complex set of conditions and influences.

Total size of farms: Tendency to lower labour requirements per acre of grass or arable crops and per unit of stock, as size increases.

Intensity of cultivation and stocking: In so far as the smaller farms are more intensively used, in particular more heavily stocked, they tend to some extent to overcome their relative disabilities in the economical use of labour.

Total tillage area: Tendency towards lower labour requirements per acre of crop as area of total tillage increases.

Total hay crop: Tendency to lower labour requirements per acre as total area increases.

Size of fields and plots:

(*a*) Tendency of size of field to increase with size of farm;

(*b*) Tendency of size of plot under any crop, especially of cereals and hay, to increase with size of field;

(*c*) Tendency of labour time requirement per acre to diminish as size of field and size of plots increases.

Irregularity of shape of farm: Tendency of walking (non-working) time of men and horses to increase with increasing irregularity of shape.

Irregularity of shape of field: Tendency of time requirement of any given operation to increase with irregularity of shape.

Some of the tendencies here indicated must not be considered as continuing without limit; they are indicated as probable and in some cases certain within the limits of circumstances of existing farms, and, up to a point, on larger farms than are commonly found in Wales. Other tendencies, such as those connected with irregularity of shape and boundaries continue to the maximum limit. It is possible to obtain approximate quantitative measures of the effects of these factors and some of these measures are given below.

Some of these items have been actually determined by human agency in the distant or recent past, while others like size of plots are modified to some extent from year to year. But some, if not all, of them have been affected by such influences as situation, contour, and soil of farm.

Natural conditions and labour requirements.

The chief of the natural conditions which determine labour requirements in farm operations are somewhat as follows:

Surface contour, slope, &c.: Ideal condition (low labour requirement), sufficient slope in one direction for natural drainage and level in the other direction, labour requirement tending to rise in varying degrees as contours vary from the ideal conditions.

Drainage: Good drainage, natural, or natural and improved or artificial; slopes and aspect exposure to wind and sun for moderate to quick drying conditions; tendency to lower labour requirement with good drainage and the quicker drying conditions.

Soil: "Light" and "heavy" in ordinary farming terminology (with which to some extent are connected drainage and drying conditions); tendency to lower labour requirements on the lighter soils.

Present "workability" or labour requirements as regards drainage and existing soil conditions may in part be due to human activities in the past.

No quantitative measures of these natural factors have yet been evolved, and at present nothing more than general judgments of their effects can be used.

Layout and general economy.

This is not to suggest that labour requirements in given operations, or the whole of the operations on a given crop or all crops, is the only consideration in respect of any of these

conditions, for it represents only one analytical approach to the subject of farm layout in relation to use of labour, capital and materials on the farms. In the total economy of the farms many other considerations arise. Small fields with their long boundaries may provide desirable shelter for livestock, or lead to the better use of the land. A stream which makes an irregular boundary may provide a valuable supply of water. One of the heavier soils may provide a much higher yield per unit of labour and materials than a light soil. The amount of improvement of natural or supply of artificial drainage will be more influenced by estimates of increases in yields than by estimates of decreases in labour requirements. These and similar considerations are of the greatest importance in general farm management, but for the moment the items indicated above are considered in relation to use of labour on the farms.

Management and layout.

There are other influences in the complex which determine the labour time required which are of an economic character; the capital equipment of the farm; relative use of manual and horse or other power; and the organising and directing ability of the farmer. These are omitted for the time being, but it must be stated that the general managerial capacity of the farmer himself is the most important factor in the adjustment of the stock and crops to the farm with all the attendant conditions of soil, contours, shape, size of fields, etc., and in the determination of the amount of labour required for the crops and stock in the circumstances under which he works. He will take steps to avoid some handicaps or difficulties, or make use of certain advantageous conditions, and, according to the degree of success attained, the influences of the conditions indicated above will be modified and the tendencies retarded. As simple illustrations: the fields of heavier soil may be left longer or permanently under grass while the lighter are more frequently or continuously under the plough; or an outlying field with a long walking-time may be left under permanent grass and even grazed by stock which require little attendance. Yet the farmer may not be a free agent and his inclinations as regards such adjustments may be modified by the necessity of ploughing to maintain good pasture. Similarly he may recognise the disadvantage of small arable fields and yet be restricted by existing layout, or the disadvantage of small plots of each crop and yet grow small plots because of the general need or desirability of a variety of crops.

Measurement of effects of various conditions.

The effects of some of the various conditions noted above may be considered individually, and to some extent collectively with reference to conditions on some Welsh farms. By the courtesy of the staff of the Soil Survey of Wales it has been possible to obtain a copy of the soil survey map of each of sixteen farms which was made specially in connection with this study.

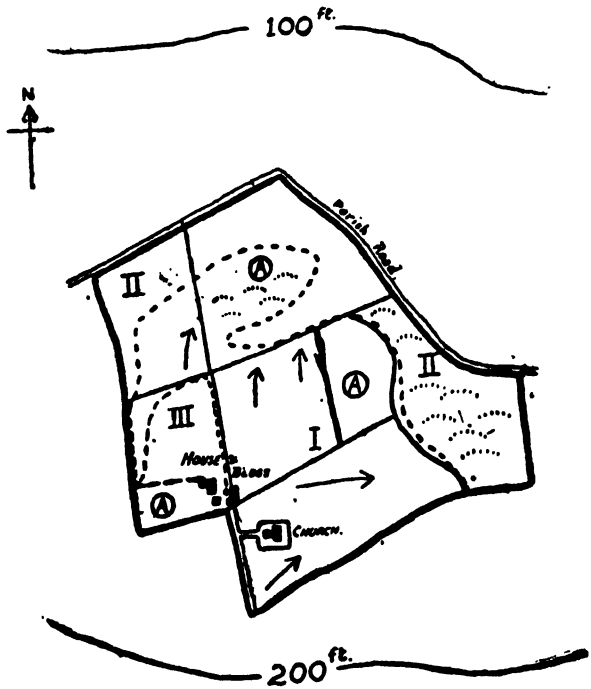
TABLE I.

Size of farms and labour requirements.

Farm No.	(1) *Cultivated area.*	(2) *Rough grazings.*	(3) *Adjusted total acreage.*	(4) *Actual total manual labour hours.*	(5) *Actual hours per acre.*		(6) *Hours per acre on standard requirements.*	
					Hours.	*Index.*	*Hours.*	*Index.*
1	49	—	49	6,463	133	162	104	130
2	60	—	60	8,584	142	173	88	110
3	68	—	68	9,589	140	171	105	131
4	89	—	89	7,986	90	110	95	118
5	94	43	107	12,617	117	143	88	110
6	113	—	113	9,954	88	107	89	112
7	121	—	121	13,241	109	133	79	99
8	141	17	145	10,846	75	92	83	103
9	146	—	146	8,877	60	73	84	105
10	143	96	167	12,835	77	94	70	88
11	191	—	191	9,191	48	59	76	95
12	196	—	196	16,825	86	105	87	109
13	320	—	320	26,157	82	100	87	108
14	127	313	190	15,112	79	96	67	84
15	127	328	192	9,516	49	60	62	77
16	89	420	173	12,583	73	89	65	81
Average	132	—	145	11,898	82	100	80	100

Sixteen farms are included, and sizes are shown in Table I above. Cultivated areas and rough grazings are stated separately. For the purpose of stating labour requirements the area of rough grazings has been divided for the lowland farms by four and for the highland farms by five, these fractions being considered representative of the difference between cultivated area and rough grazings. But in this connection it must be remembered that actual work on stock pastured on rough grazings is attributed as to the stock itself.

Farms 5, 8, 10 are all lowland and heavy land farms, but the rough grazings of No. 10 are of hill character, while in the other cases they are of the marshy character. Nos. 14, 15, 16 are typical hill farms and characteristically small fields on the improved land are associated with the upland rough pasturage.



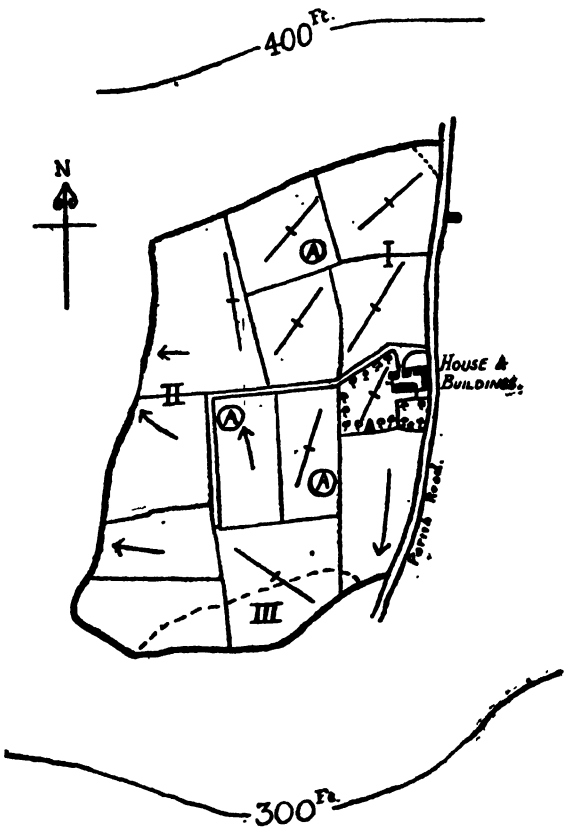
1. Farm area, 49 acres
Average size of fields 8.1 acres.
Average distance to fields 88 yards.
Soil types—I: Ebenezer—Penrhyn Series—Light Loam. II: Sion Series—Peaty medium loam. III: Ebenezer Series—Sandy light loam.

The average size of fields and plots on the cultivated land is found to be

	Mean size.		Size of field. acres.	Size of plot. acres.
	Cultivated area.	Adjusted area.		
Farms 1 to 4 ...	66	66	5.6	2.6
Farms 5 to 9 ...	123	126	6.0	3.8
Farms 10 to 13 ...	212	218	10.7	4.7
Farms 14 to 16 ...	114	185	6.6	2.9

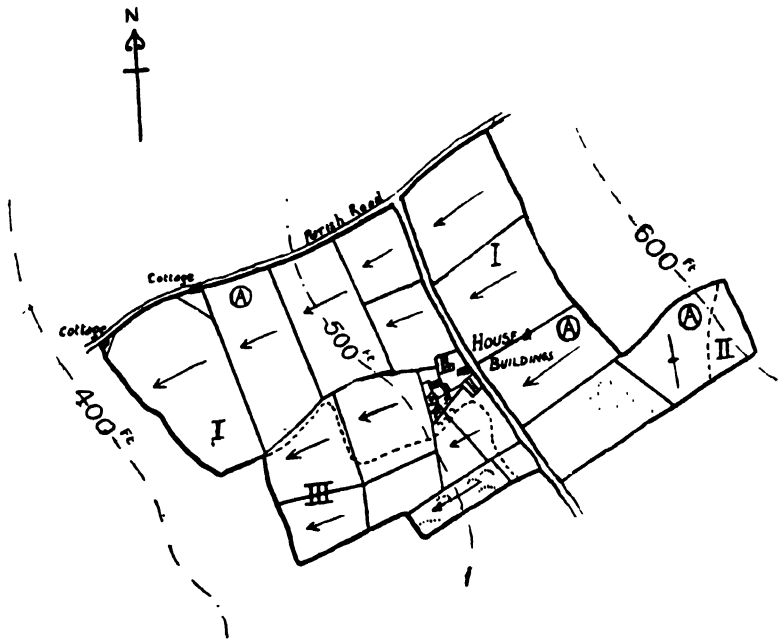
Size of farm.

Although there is a general tendency for the amount of labour required to diminish as the size of farm increases, the influence of the total size is modified to some extent, and in



2. Farm area, 60 acres.
Average size of fields 5.0 acres.
Average distance to fields 238 yards.
Soil types—I: Ebenezer Series—Sandy light loam. II: Ebenezer Series—Sandy loam. III: Sion Series—Medium loam.

specific cases to a very great extent, by the tendency towards more intensive use of land on the smaller farms, especially by high complement of live stock. The crude measure of variation in labour requirement by size of farm is given in column 5 of Table I above, but when allowance is made for the greater intensity of use of land the more accurate measure is shown in columns 6.



3. Farm area, 68 acres.
Average size of fields 4.9 acres.
Average distance to fields 136 yards.
Soil types—I: Ebenezer—Penrhyn Series—Light to medium loam. II: Ebenezer Series—Stony light loam. III: Sion Series—Medium to heavy loam.

TABLE II.

Average size of field.

Farm No.	Cultivated area.	Average size of cultivated fields (acres).			
		Arable.	*Hay.*	*Pasture.*	*All fields.*
1	49	7.5	8.7	10.0	8.1
2	60	5.1	5.6	5.0	5.0
3	68	5.2	5.9	4.0	4.9
4	89	7.1	6.7	5.7	5.9
5	94	4.7	5.2	4.3	4.9
6	113	7.1	6.3	4.6	7.5
7	121	6.8	6.2	8.7	7.5
8	141	6.5	5.7	5.4	5.9
9	146	5.1	6.5	4.5	5.2
10	143	7.5	8.4	9.7	8.4
11	191	8.5	8·8	8.6	8.7
12	196	11.8	11.7	9.5	10.3
13	320	11.8	14.3	18.0	15.2
14	127	7.7	10.2	7.6	9.0
15	127	8.9	7.0	6.7	7.0
16	89	5.2	5.2	4.2	4.5
Average	132	7.2	7.7	7.3	7.4

The fields included in the Table represent the cultivated area of the farms, for rough grazings, woodlands, etc., have not been included. The distribution of fields of different sizes was as follows :—

TABLE III.

Distribution of size of fields.*

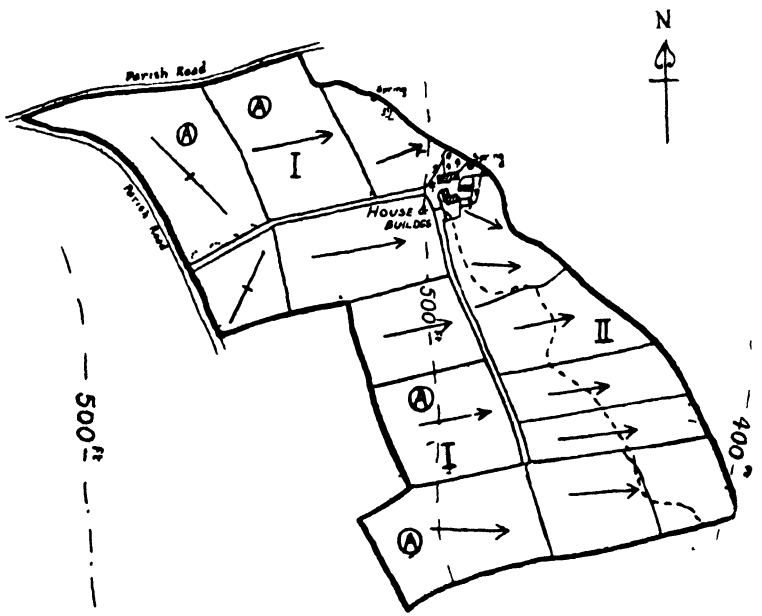
	3 acres and under.	*3–4 acres.*	*4–5 acres.*	*5–6 acres.*	*6–7 acres.*	*7–8 acres.*	*Over 8 acres.*	*Total.*
Farms up to 100 acres.	7	7	16	16	5	4	11	66
Farms 100–150 acres.	22	16	15	22	16	17	45	153
Farms over 150 acres.	1	0	3	3	3	4	48	62
All farms.	30	23	34	41	24	25	104	281

* The figures in Tables III and IV cover two years, for the same farms in each year, and must be divided by two to give the true figure for each year, but where odd numbers are shown, *e.g.*, 5, the figures are to be read as three in one year and two in the other. Actual areas in use vary a little from year to year.

On the majority of the farms some of the fields under arable crops were sub-divided into smaller plots. This happened most frequently with root crops, potatoes, and green crops when the field might carry four or more different crops each occupying a separate plot in the same year. The preliminary ploughing would be done in most cases on the basis of the whole field, but subsequent cultivations and handling such as manuring, planting, cleaning and lifting or harvesting would be for each plot separately. This feature was very marked on some of the smaller farms, where it was not infrequent to find small plots of less than half an acre of mangels or swedes and perhaps a small field of about three acres, handled as three or more small plots.

Average size of plots: sixteen farms.

	Acres.
Cereal crops	4.9
Root crops	1.9
All tillage crops	3.6



4. Farm area, 89 acres.
Average size of fields 5.9 acres.
Average distance to fields 237 yards.
Soil types—I: Penrhyn Series—Shaly medium loam. II: Cegin Series—Heavy silt loam.

The fields were divided into two or more plots for cereal crops only on farms where the size of the field was not in proportion to the tillage area on the farm. The general tendency is for the average size of the fields to vary in proportion to the total acreage of the farm, but there are some variations from this tendency. Adjustments are made on the farms, and the correlation between the average size of the plots of arable crops on each farm and the total tillage acreage was very high.

TABLE IV.

Distribution of size of plots: sixteen farms.*

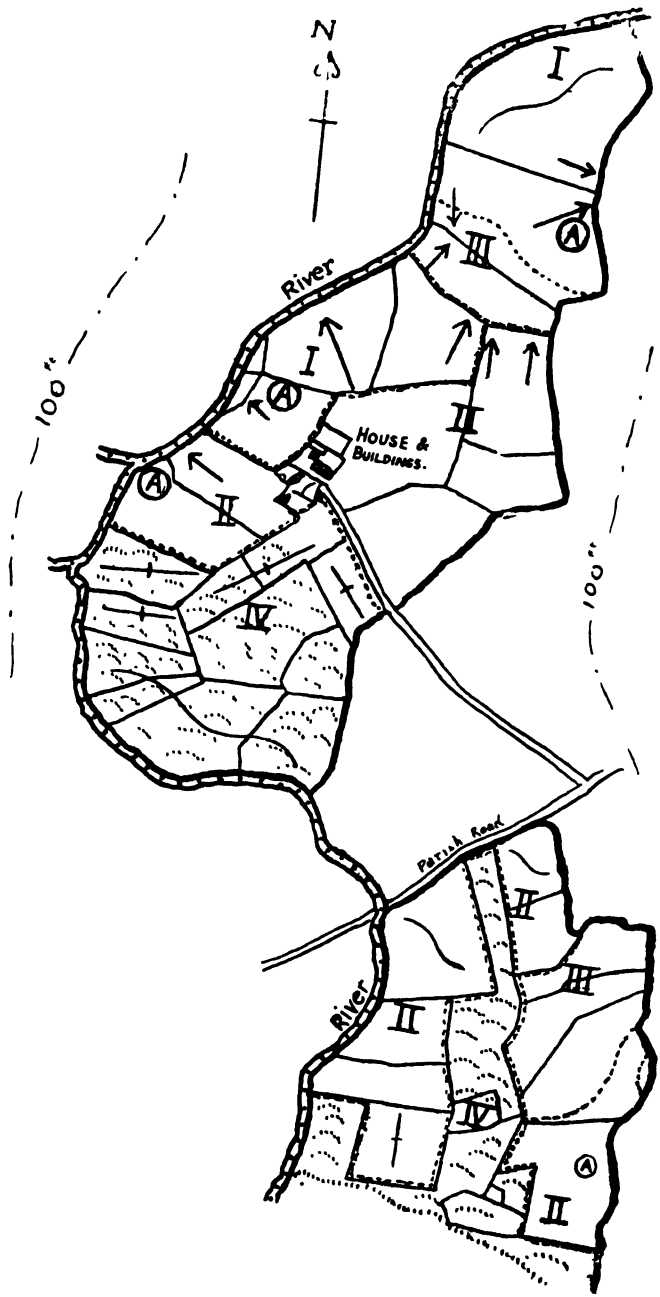
	Number of Plots.							
	Under 3 acres.	*3–4 acres.*	*4–5 acres.*	*5–6 acres.*	*6–7 acres.*	*7–8 acres.*	*Over 8 acres.*	*Total.*
Cereals.								
Farms up to 100 acres ...	10	11	7	5	2	1	—	36
100–150 ...	14	16	17	14	6	1	6	74
150 and over ...	7	5	1	3	2	3	13	34
All farms ...	31	32	25	22	10	5	19	144
Roots.								
Farms up to 100 acres ...	11	18	4	—	—	—	—	33
100–150 ...	19	18	13	6	1	—	—	57
150 and over ...	2	9	6	4	1	—	2	24
All farms ...	32	45	23	10	2	—	2	114
All arable crops.								
Farms up to 100 acres ...	21	29	11	5	2	1	—	69
100–150 ...	33	34	30	20	7	1	6	131
150 and over ...	9	14	7	7	3	3	15	58
All farms ...	63	77	48	32	12	5	21	258

* See note to Table III.

The size of plot is an important feature in economy of labour with arable crops. Much time of men and horses is wasted in turning owing to the short lengths on all horse labour operations.[2] The labour requirements are unduly large on account of this with root crops which have a high normal labour requirement.

As previously stated there is a close association between the total area of tillage and the average size of the plot planted

[2] A point which does not directly arise here, but one of some importance as regards returns on labour, is that with most small fields there is a high proportion of headlands to other land in the fields, and in so far as headlands may fail to be planted or give lower yields, the total yields and average yields per acre are reduced. In any case, where the proportion of headlands to other land is high, time requirement in horse tasks tends to be high because of time in cultivating headlands, in addition to the extra turning-time.



5. Farm area, 107 acres.
Average size of fields 4.9 acres. Average distance to fields 581 yards.
Soil types—I: Penrhyn—Ebenezer Series—Stony light to medium light. II: Cegin Series—Medium loam. III: Cegin Series—Heavy loam. IV: Cegin Series—Heavy loam.

to arable crops such as roots or cereals. There is also a close association between the average size of plot and the labour time required in cultivating, planting, etc., and harvesting of crops.

LEGEND.

——→ Gradually sloping ground.
——|→ Fairly steep slope.
——||→ Very steep slope.
——+ Level ground.
——— Field boundaries.
▬▬ Farm boundaries.
Soil types—Roman numerals.
- - - - - Soil boundaries.
Ⓐ Arable fields.
~~~~~~~~~~ 200 Altitude line.

Distance from homestead to fields:

The length of road from the farmyard to the gate of each of the fields (excluding rough grazings) was measured on the maps and the average calculated for each farm. This gives a good indication of the arrangement of the fields for economy in working and provides one measure for comparison of layout between individual farms (see actual distances set out in table).

Average distance from yard to field gates.

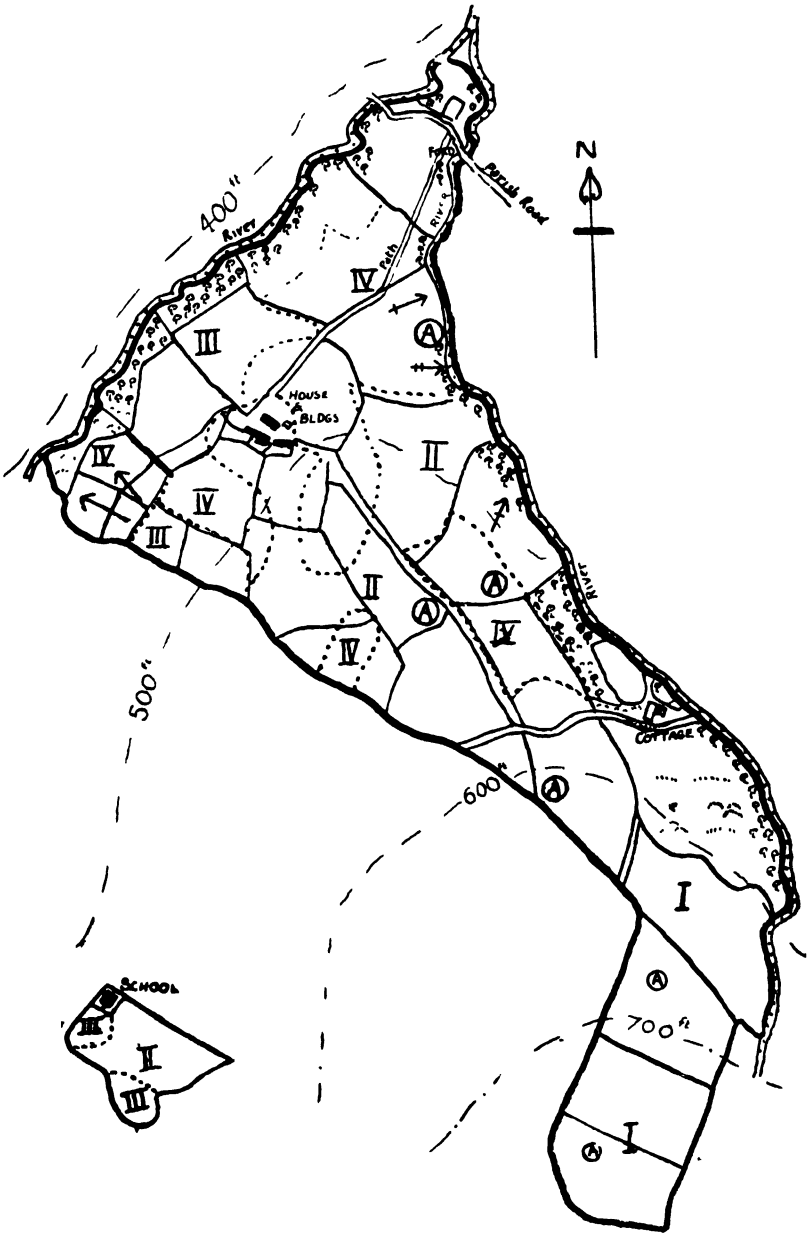
Farm number.	*Average distance to field gates.*	*Farm number.*	*Average distance to field gates.*
	yards.		yards.
1	88	9	418
2	238	10	412
3	136	11	405
4	237	12	800
5	581	13	794
6	213	14	158
7	235	15	567
8	391	16	460

Average on all farms = 482 yards.

Distance from homestead to fields measured in yards does not, however, provide a true index of the variation from farm to farm. In many cases the distance to be travelled is comparatively short, but the gradient is steep either towards or away from the farmyard. The nature and the direction of the slope for each farm can be judged by the contours included on the maps and the arrows added from the soil survey.

Taking a representative arable rotation on mixed farms in Wales somewhat as follows

(1) Oats
(2) Oats or mixed corn
(3) Roots
(4) Barley
(5) Hay
~~~~~~~~~~



8. Farm area, 145 acres.
Average size of fields 5.9 acres.
Average distance to fields 391 yards.
Soil types—I: Penrhyn Series—Medium loam. II: Penrhyn Series—Medium to heavy silt loam. III: Cegin Series—Medium to heavy silt loam. IV: Cegin Series—Heavy loam.

the number of man and horse trips per acre to and from the field would be approximately

	Man trips.	*Horse trips.*
First year (cereal) ...	16	17.5
Second year (cereal) ...	16	17.5
Third year (potatoes) ...	70	50.0
Fourth year (cereal) ...	16	17.5
Fifth year (clover hay)	7	5.0
	125	112.5

In this calculation it has been assumed that horses and men work an average of eight hours per day divided into periods of about four hours each. The number of trips made for each crop would vary from farm to farm according to the dressing of farmyard manure applied and the yield of crop to be carted from field to the rickyard. But the above estimates represent conditions on some Welsh farms. Taking the " round trip " from the homestead to field in each case, and taking the average distance to fields at approximately a quarter of a mile, the total distance walked over the rotation per acre would be 62½ man miles and 56¼ horse miles. At a walking speed of one mile in 22½ minutes this would be equivalent to 23½ hours spent in travelling to and from the house by men and 21 hours by horses. The further the field from the house the longer the time spent in unproductive walking. With a field under rotation at a distance of half a mile from the house from 10—15 per cent. of the total labour requirements for the arable crops would be spent in walking to and from the field by men and horses. This extra cost in cultivation is well recognised by farmers, and fields near the homestead are generally utilised more intensively than those further away. In many cases the farthest fields are kept permanently under grass, little use being made of them except for pasturing sheep or strong store cattle.

Length of fences. As has been shown above, the length of fencing varies with the size of fields and the shape of field boundaries. Likewise the length of farm boundary varies with the general shape of the whole farm. The average length of boundary line per acre for the farms in this sample is set out below.

The length of boundary fence that each farmer has to maintain will also vary according to the nature of the boundary. In the case of a farm bounded by roads, the whole length of boundary fence has to be maintained, whereas with a common

Length of total boundary line per acre.

Farm number.	*Boundary line per acre.*	*Farm number.*	*Boundary line per acre.*
	yards.		yards.
1	46	9	35
2	39	10	46
3	45	11	29
4	42	12	42
5	52	13	34
6	32	14	32
7	32	15	54
8	39	16	56

Average all farms = 40 yards.

boundary fence between farms the work of maintenance is usually shared.

Taking the total length of field fences inside the farm with the outside boundaries, the total hedges and fences per acre on each of the farms was as follows :—

TABLE V.

Length of fences and establishment labour per acre.

Farm No.	*Fencing per acre.*	*Establishment labour per acre.*	*Farm No.*	*Fencing per acre.*	*Establishment labour per acre.*
	yards.	hours.		yards.	hours.
1	77	5.2	9	83	7.2
2	103	22.2	10	82	16.2
3	106	13.9	11	80	8.4
4	90	8.2	12	112	9.9
5	136	13.9	13	74	8.9
6	119	18.5	14	81	10.9
7	72	13.9	15	177	7.6
8	121	16.5	16	184	13.7

Average fencing per acre = 106 yards.

Average establishment labour per acre = 11.6 hours.

The amount of labour time spent in maintenance of field fences varies partly according to the length of fence per acre on farms, but mainly with the kind of hedge or fence or both. On some of the upland farms the cost of maintenance is mainly in connection with wire fences, whereas on many lowland farms the works consist in the main of trimming and clearing the hedges and cutting the brushwood at intervals. The amount of establishment labour requirement is also influenced by the length of farm roads maintained. First, these are bounded by a hedge or fence on either side and secondly there is the work of cleaning

and repairing. Farm buildings situated near a public road with land laid out conveniently hold a great advantage in labour cost over those away from the road and with an inferior layout of fields.

General index of layout.

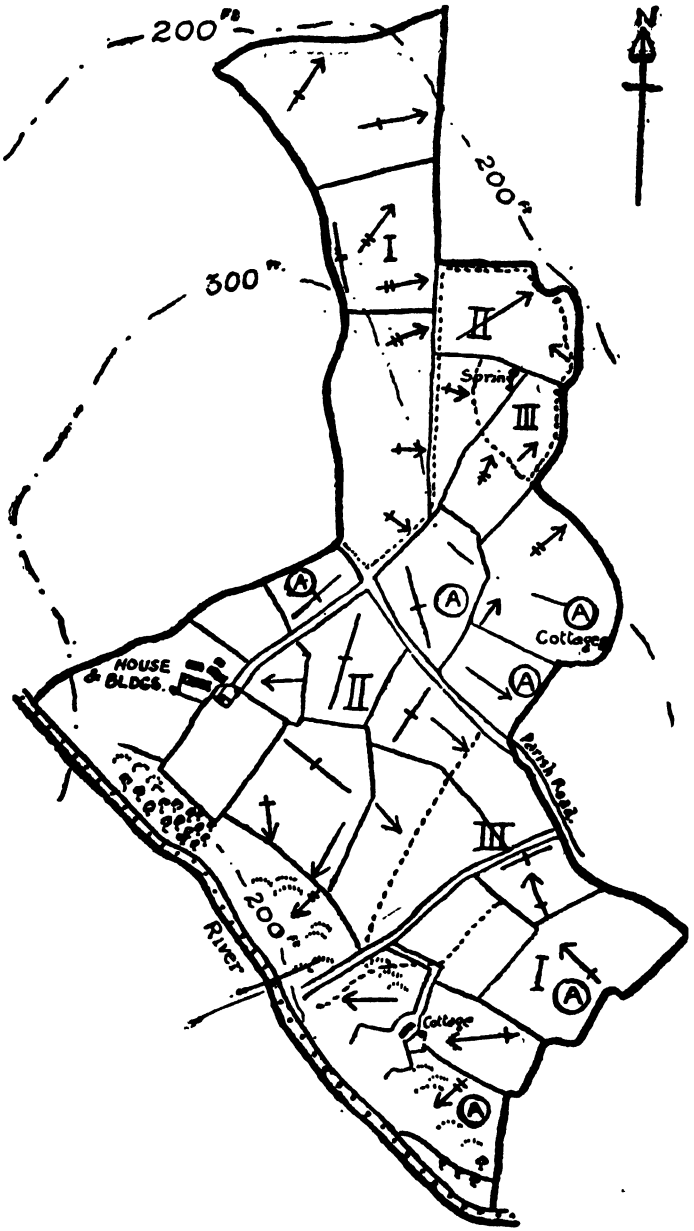
Taking together these items—general shape of farm and average distance from farmstead or yard to field-gates; length of fences per acre; average size of field and average size of plot; the total of the qualities of layout as determined by human agency can be measured. As stated above no quantitative measures of the *natural* factors such as contours and slopes, light

TABLE VI.

General index of layout.

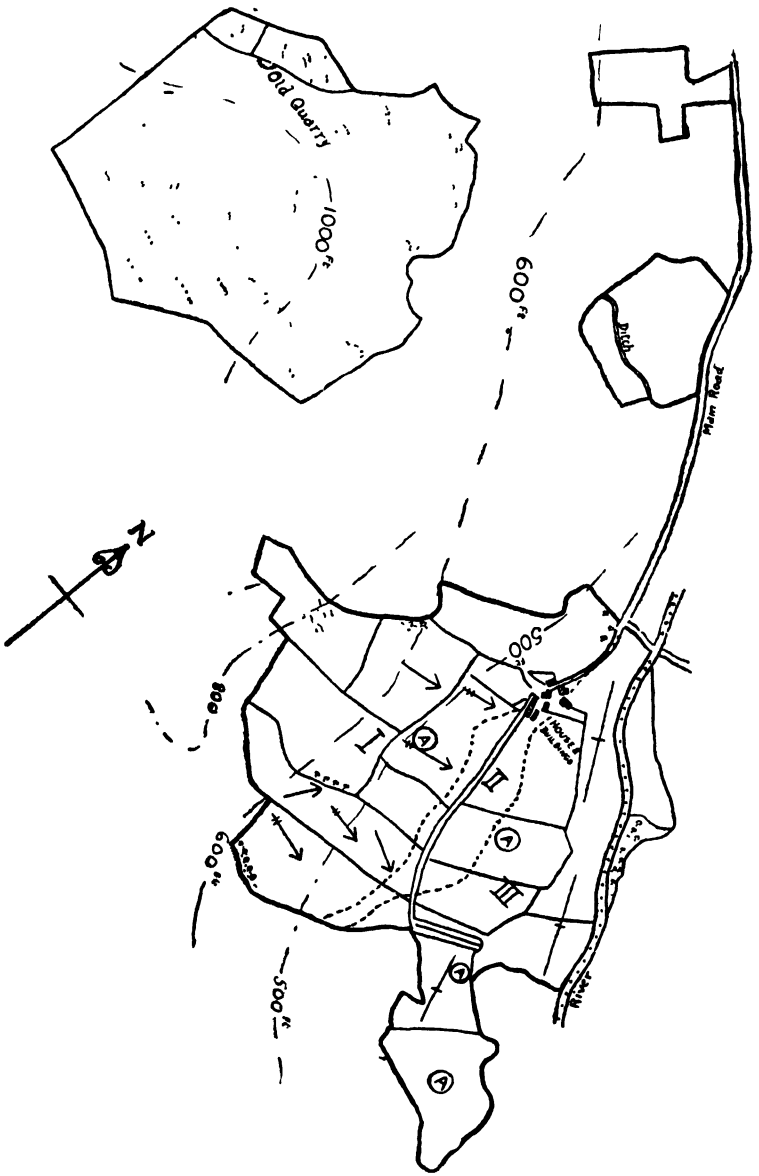
Farm No.	*General shape: boundary line per acre.*	*Average distance of field gates from yard.*	*Length of fences per acre.*	*Average size of field.*	*Average size of plot.*	*Index of layout.*
	yards.	yards.	yards.	acres.	acres.	Index.
1	46	88	77	8.1	1.45	93
2	39	238	103	5.0	2.46	104
3	45	186	106	4.9	2.35	105
4	42	237	90	5.9	3.55	94
5	52	581	136	4.9	2.23	133
6	32	218	119	7.5	3.35	91
7	32	235	72	7.5	4.15	80
8	39	391	121	5.9	4.19	103
9	35	418	83	5.2	3.84	98
10	41	412	82	8.4	4.07	90
11	29	405	80	8.7	3.60	85
12	42	800	112	10.3	5.42	100
13	34	794	74	15.2	5.44	75
14	32	158	81	9.0	2.89	80
15	54	567	177	7.0	2.54	134
16	56	460	184	4.5	3.35	134
Average	40	482	106	7.4	3.64	100

and heavy soils are available, but were they available it is quite possible that an almost complete measure of causes of probable variations in labour requirement from farm to farm could be obtained. A general index of the layout factors is given in the



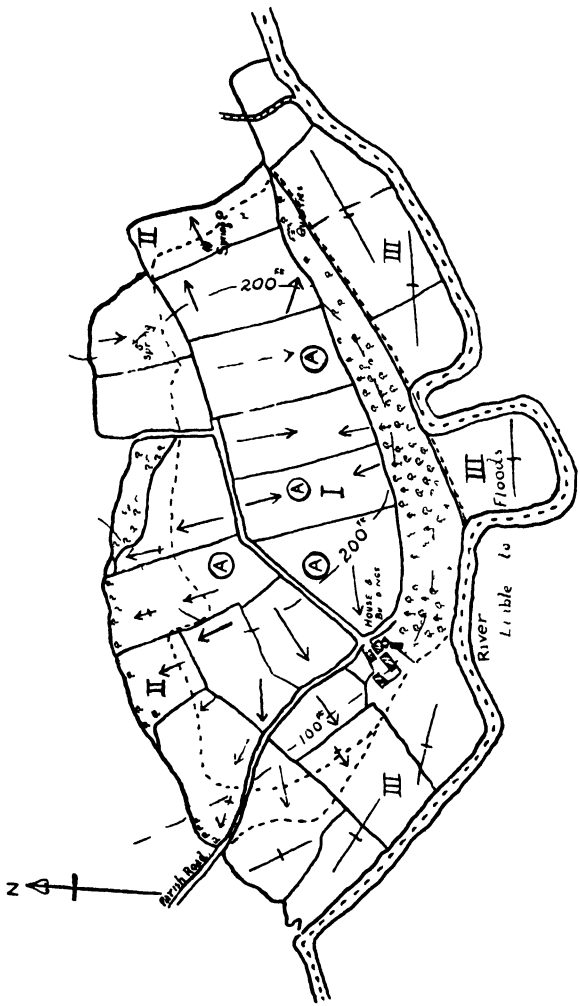
9. Farm area, 146 acres.
Average size of fields 5.2 acres.
Average distance to fields 418 yards.
Soil types—I: Powys Bangor Series—Shaly light to medium loam. II: Penrhyn-Ebenezer Series—Stony medium to heavy loam. III: Cegin Series—Heavy silt loam.

final column of Table VI above. This indicates the approximate variations in labour-time requirements per unit of crops and stock likely to arise from conditions of layout from farm to farm if



10. Farm area, 167 acres.
Average size of fields 8.4 acres.
Average distance to fields 412 yards.
Soil types—I: Powys Series—Shaly heavy loam. II: Conway Series—Stony light to medium loam. III: Conway Series—Heavy silt loam.

certain farmers concerned did not arrange to overcome the handicaps and disabilities offered by the layouts of their farms. As may be seen, the variations in quality of layout are extremely wide—as between 75 and 134—and are greater than the actual variations found in labour requirements. But as indicated above



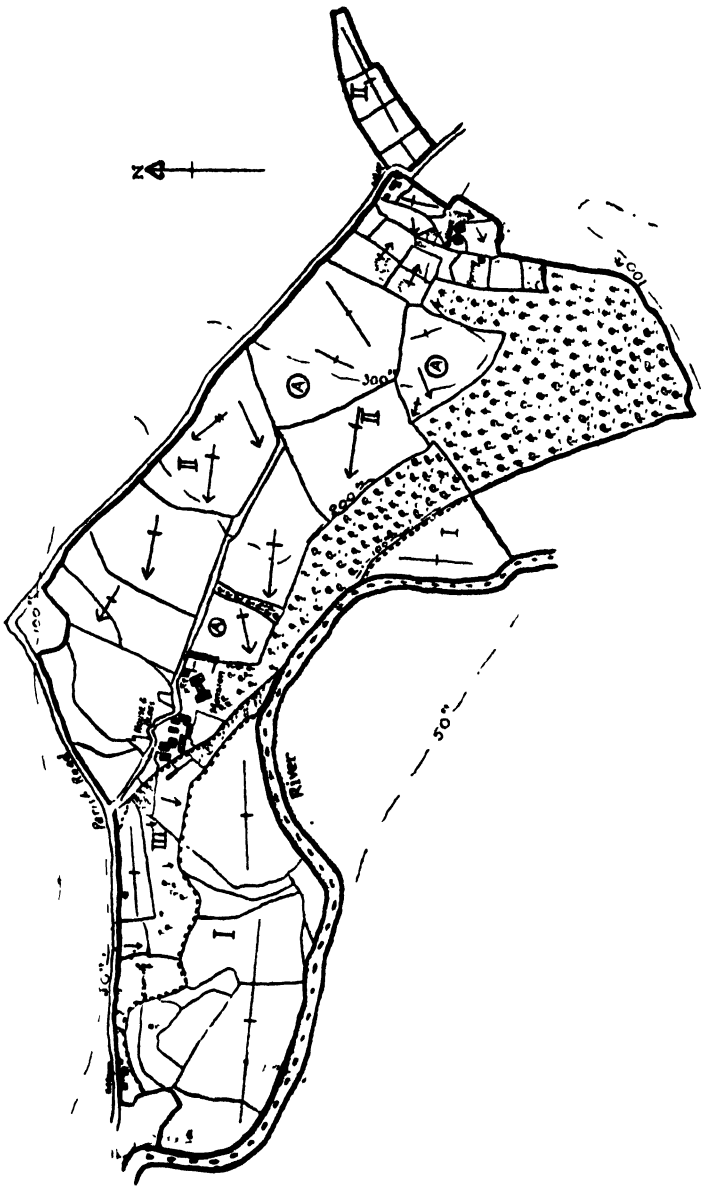
11. Farm area, 191 acres.
Average size of fields 8.7 acres.
Average distance to fields 405 yards.
Soil types—I: Powys Series—Medium loam. II: Cegin Series—Clay loam. III: Conway Series—Medium silt loam.

farmers can and do modify their operations to make the most of some advantages and to overcome some of the handicaps offered by poor layouts.

Notes on individual farms.

The following notes on individual farms bring together as far as possible the items of layout and some natural conditions :—

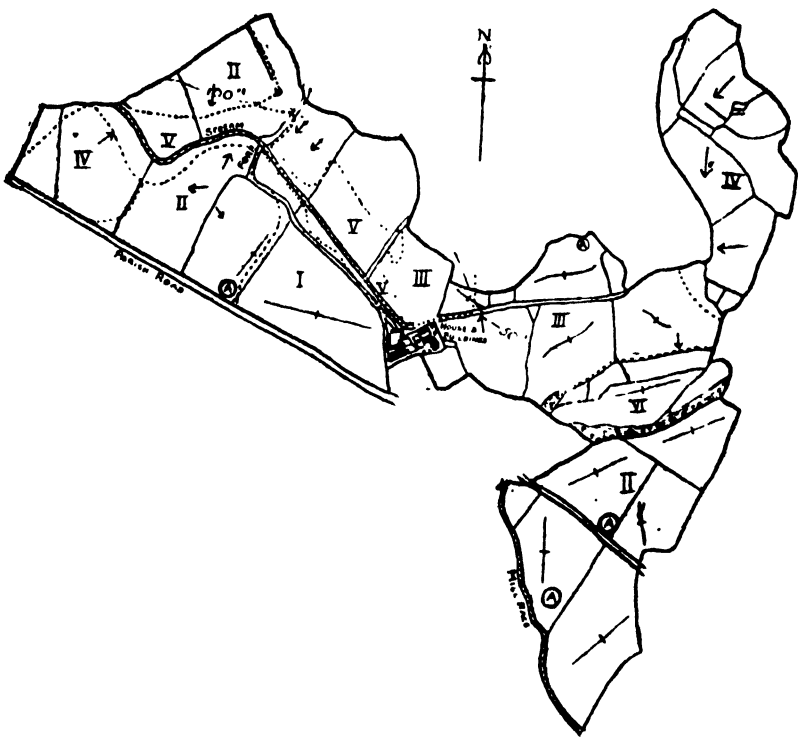
1. Small, but good shape, fields and plots comparatively large for a small farm. Layout generally good. Mixed soils tending to be of light character. Labour require-



12. Farm area, 196 acres.
Average size of fields, 10.3 acres. Average distance to fields 800 yards.
Soil types—I: Conway Series—Heavy silt loam. II: Powys Series—Shaly medium to heavy loam. III: Pearbyn Series—Medium to heavy loam.

ment high because of fairly intensive use, but high also because of size, and low economy of labour on the small farm.

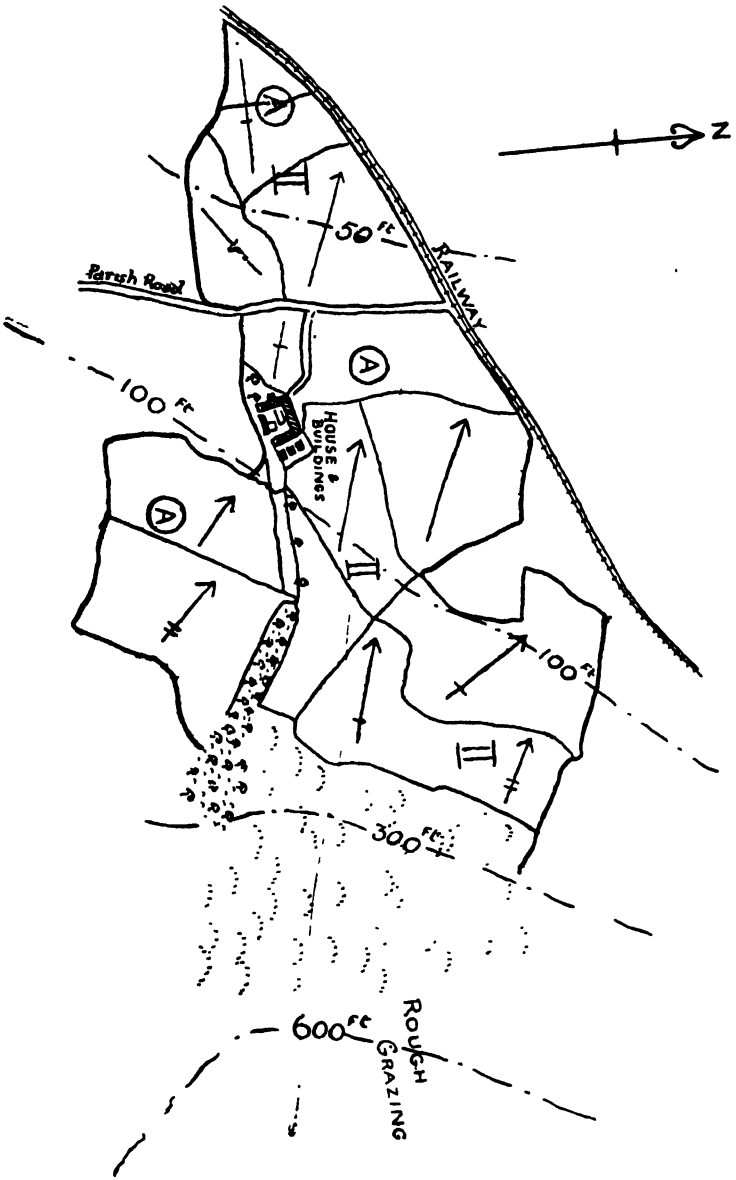
2. Small farm, fairly good shape and layout, size of fields fitted to size of farm, and layout in general fair. Soil is uniform, and on the light side. High amount of labour used because of relatively intensive use of land, and also because of small size of farm.
3. Small farm, resembling No. 2, but slightly better layout. Soil variable, medium to heavy, tending to heavy character. Actual use of labour about the same as No. 2, but because of more intensive use of land, the actual



13. Farm area, 320 acres.
Average size of fields 15.2 acres.
Average distance to fields 794 yards.

Soil types—I: Ebenezer series—Sandy light loam. II: Ebenezer Series—Light loam. III: Sion Series—Medium loam. IV: Sion series (inferior)—Medium to heavy loam. V: Glanadda Series (inferior)—Medium loam. VI: Glanadda Series—Medium loam.

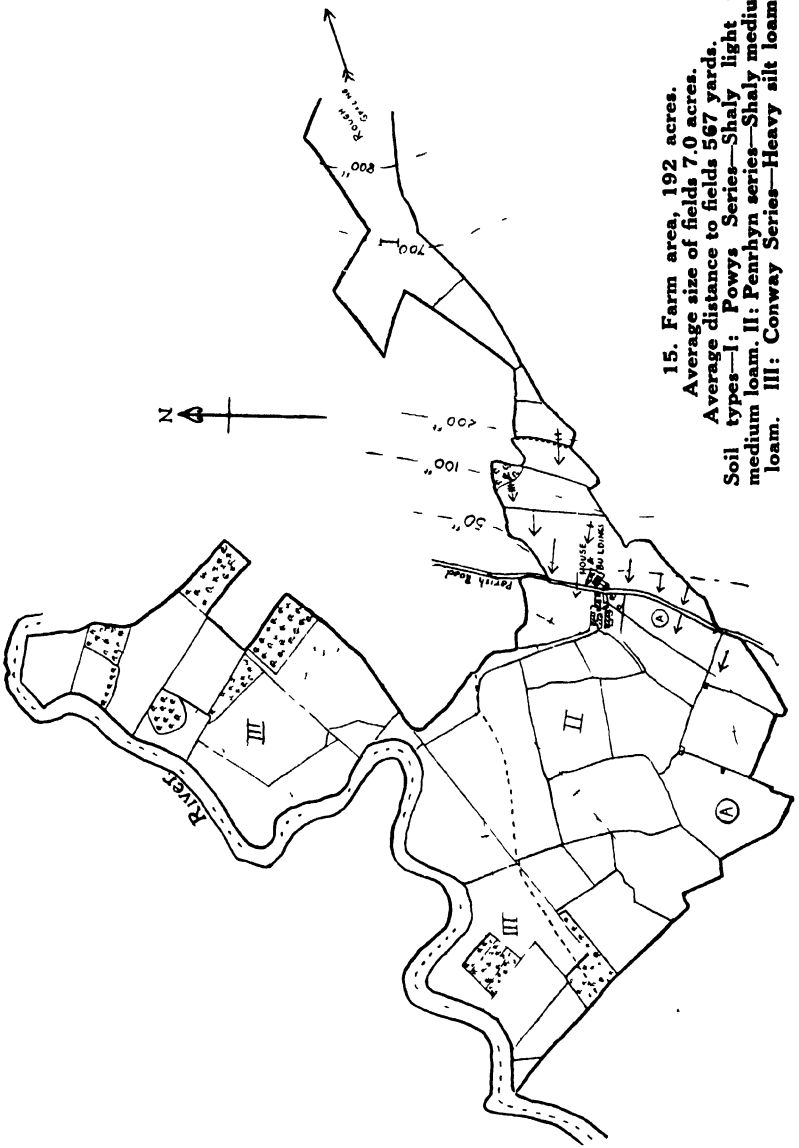
amount used is not so high in relation to the requirement measured on standard basis. The effect of the heavier soil appears to be balanced by slightly better conditions of layout.



14. Farm area, 190 acres.
Average size of fields 9.0 acres.
Average distance to fields 158 yards.
Soil types—I: Powys Series (open hill)—Shaly light to medium loam. II: Penrhyn Series—Shaly medium silt loam. III: Penrhyn Series—Medium to heavy loam.

4. One of the smaller farms, fields of good size, and good general layout. Fairly uniform soil, tending to be light and easy working but some handicap of slope. Amount

of labour used is fairly high, but as the actual amount used is less than the estimated standard requirement there is economical use of labour to which the layout and soil contribute.

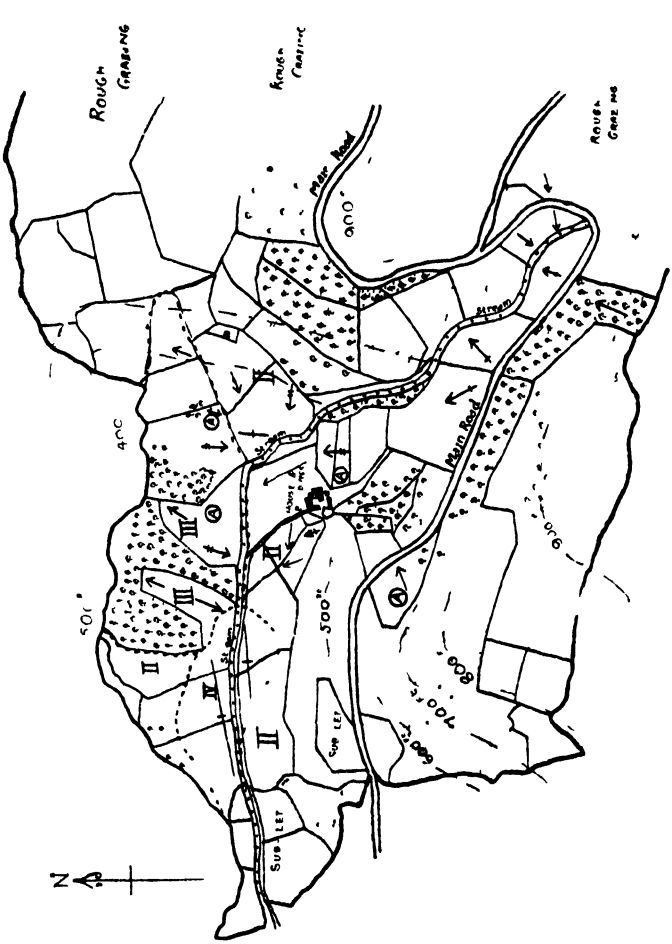


15. Farm area, 192 acres.
Average size of fields 7.0 acres.
Average distance to fields 567 yards.
Soil types—I: Powys Series—Shaly light to medium loam. II: Penrhyn series—Shaly medium loam. III: Conway Series—Heavy silt loam.

5. Farm of 108 acres, with some rough grazings of the marsh type. Very poor general shape and distribution, fields tending to be small and irregular in shape. Soil tends

to be wet and heavy. Actual amount of labour used is very high, especially against the estimated standard requirement. High labour requirement due to poor layout and heavy working soil. A very difficult farm to work.

6. A medium sized farm of good general layout, fields of good size but rather irregular in shape and quite irregular in contour. Soil variable, medium, to heavy



16. Farm area, 173 acres.
Average size of fields 4.5 acres.
Average distance to fields 460 yards.
Soil types—I: Powys Series (upland)—Shaly medium silt loam. II: Penrhyn Series—Medium to heavy silt loam. III: Powys Series (lowland)—Stony or shaly medium loam. IV: Cegin Series—Heavy silt loam.

in parts. Actual labour used about normal in amount and about equal to estimated standard requirements. A fairly good layout balances some natural handicaps.

A medium sized farm of fairly good layout, fields of good size but of rather irregular shape. But general arrangement and layout quite good. Soil is fairly uniform and

on the whole light and easily worked. Actual amount of labour used is high, and standard requirement about normal, but there were special circumstances in respect of use of labour in connection with stock on this farm.

8. One of the larger farms, of poor general shape with rather small fields of irregular shape. Soil is very variable, including a portion of heavy silt loam. The low amount of labour used is to be attributed mainly to the economy of use of labour on the larger farm.

9. About the same size as No. 8, again with poor shape and fairly small fields, but on the whole a better layout than No. 8. Soil fairly uniform, tending to be light. Labour requirements on standard basis about the same as No. 8, but actual amount used is lower. Again relative economy of labour on the larger farm is shown.

10. Another farm of the same size as No. 8 and 9, but with a portion of rough grazings. Fields of fair size, and general layout very good. Soil fairly uniform, but of heavy character. Labour requirement tending to be higher than normal for farms of this size largely because of heavy soil.

11. One of the larger farms, of good general shape, fields of good general shape, and altogether a good layout. Soils variable, with clay loam in parts. Contours uneven. Good layout and large size tend to low labour requirement. Actual amount of labour used is low when measured against the estimated standard requirement.

12. Another of the large farms, of poor general shape, with large fields but of irregular shape. General layout about average. Fairly uniform soil, of heavy type. Theoretical requirements of labour are high and actual amounts used are about equal to standard requirements. The economy of size here tends to be balanced by the layout conditions. The difference between No 11 and No. 12 largely arises from poorer layout and heavier soil in the latter.

13. The largest farm in the group, of very poor general shape, but fields are large and of fairly good shape. On balance, the general layout here is good, for size of field and plot counteract the handicap of general shape to some extent. Soil variable, but tending to be easy working, and farm is fairly level. The labour requirement is high because of intensive use, especially by stock. The economy of the large farm in use of labour is shown,

but is counteracted by the very poor general shape.

14. One of the rough pasturage farms. Layout of enclosed land is good, and size of field fair for this type of farm. Variable soil, light to heavy loam, fairly sharp contours. Actual amount of labour used is fairly high, and in excess of standard requirements.

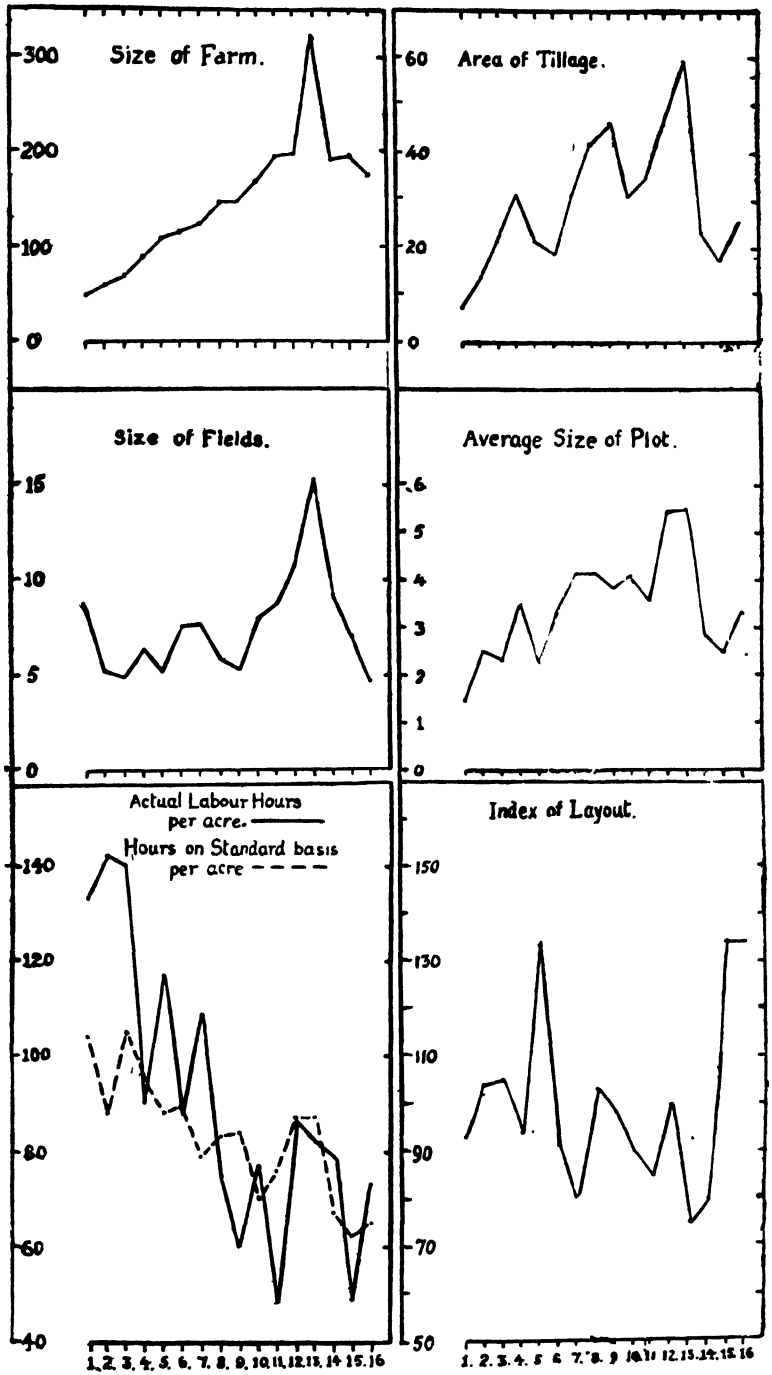
15 Very poor general shape, but with fields of good size over the better portion of the cultivated area. On the whole, general layout conditions are very poor. Soil fairly uniform and easy working. Labour requirements are low, both actual and measured against standard requirements. Easy working soil and fairly good conditions on the better part of the farm balance against very poor general shape.

16. A farm of very poor general shape, badly broken up, and with very small fields. General layout conditions very poor. Soil variable, heavy in parts. Amount of labour used is high, and high against standard requirements. Poor conditions of layout lead to loss of economy in working.

Summary.

The main factors in the determination of amount of manual labour-time required per acre, as arising from the layout of farms, are illustrated in Diagram 1, where the size of farm and other conditions are compared with the actual labour-time per acre, and with the estimate of time required on the basis of standard requirements of the crops and stock on each farm. The actual hours per acre, which include the time given to crops, stock, and " establishment " work, and thus include under " acre " both the land and the stock upon it, shows a tendency to decline from the smaller to the larger farms. But this decline is not in proportion to the increase in size of farm. There is greater intensity of use, especially of stocking, on the smaller farms and the figures for actual hours per acre (Table I, column 5 and Diagram) represent two items (*a*) the relative disability of the smaller farms in use of labour, and (*b*) the greater intensity of stocking on these farms, and these two tendencies are pulling in opposite directions. Thus, to some extent, the smaller farms overcome their disabilities in use of labour by heavier stocking and more intensive use of land. When the labour-time requirement for each farm is calculated on a standard basis (Table I, column 6, and Diagram) these two factors are separated, and the hours thus calculated, which show the relative disability of small farms in use of labour, show much less variation than is found in the actual hours per acre.

DIAGRAM 1.


Size of Farm.
300
200
100
0
Area of Tillage.
60
40
20
0
Size of Fields.
15
10
5
0
Average Size of Plot.
6
5
4
3
2
1
0
Actual Labour Hours per acre.
Hours on Standard basis per acre
140
120
100
80
60
40
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16
Index of Layout.
150
130
110
90
70
50
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16

Factors of layout and labour requirement.

Reference to Diagram 1 shows a general tendency for area of tillage, size of field and size of plot to vary with the size of farms, but as would be expected there are some individual variations from this tendency because of the circumstances which have determined the layout of individual farms. The index of layout, or, more properly, the index of probable influence of layout on labour requirements, shows that the conditions of layout are individual to each farm, and that the quality of layout does not vary with the size of farms. Large farms may tend more frequently to poor general shape than the smaller farms, but some small and medium sized farms may suffer from this handicap.

In specific cases some of the causes of high and low economy of use of labour may be identified. On Farms 5 and 16, for instance, poor general layout and heavy working soil conditions cause comparatively heavy use of labour. Again, on Farm 9 the economy of size, fairly good layout and light working soil, lead to high economy of labour, and on Farm 11 the economy of size and good layout lead to high economy of labour in spite of heavier working soil.

But management of land, and of stock upon the land, as well as the important factor of the organisation and use of the labour force itself, are inevitably factors in the economy of the use of labour.

There may be cases in which some of the disadvantages of existing layout might be modified or removed and where this could be done economically some economic advantage would be secured in the use of the land itself or in the use of labour with the crops and stock. If the improvement or modification of layout is not possible on any considerable scale, the differences between one farm and another in the amount of labour required for production of crops and livestock must be recognised, for there are real differences in costs arising from the conditions of layout of farms. Some of these differences are doubtless reflected in rents and capital values of farms, but it is more probable that some of them are more clearly reflected in labour costs and in profits of farmers because their importance in the working of the farms has not been clearly recognised. Higher costs per hour of labour bring these differences in working economy into greater prominence.

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Provenance of this paper.

The maps for this study, with indications of slopes and soil types, etc., were made by Messrs. D. O. Hughes, M.Sc., and

Brynmor Jones, M.Sc., of University College, Bangor. The method of classification used is that adopted in the Soil Survey of Wales. We have been very grateful for their interest and collaboration and only regret that it has not been possible to make the more complete use of the detailed surveys of these farms which is merited. Mr. Davies was responsible for the final analysis of all data used, and for the preparation of this study, but in the course of years the investigation upon which the study is based has been served by several people, notably Mr. J. Morgan Jones, M.A., Mr. Thomas Lewis, B.Sc., Miss Dorothy Davies, and Mr. G. O. Williams. All those who have been concerned with the recording and field-work for the investigation would express their gratitude to the farmers whose great interest, loyalty, and painstaking effort made such an investigation possible. The laboratory of the student of farm management consists of a number of farms, their managers are co-workers with the student, and their assistance is deeply appreciated. But the Department of Agricultural Economics, and Mr. Davies, take full responsibility for all statements made in presenting the results of this study.—A. W. Ashby.

FARMERS' CONTROL OF AUCTION MARTS IN WALES.

By Thomas Lewis, B.Sc., M.S.,

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Welsh farming as a whole derives over 90 per cent. of its income from the livestock industry. The actual proportions of income derived from the different branches of production vary from farm to farm and from area to area. Mountain farms may derive the whole of their income from the sale of store stock, whereas a lowland dairy farm may derive 70 or 80 per cent. of its income from the sale of liquid milk alone. Between these extremes all degrees of variation are found, but on all farms the sale of livestock either in store or fat condition represents a very large proportion of the farm income—the largest proportion, even

when compared with the products of livestock, such as milk, cheese, butter, wool, etc. Marketing problems are therefore largely those of marketing livestock, and every practicable method of improving the system must be considered.

Unfortunately marketing systems cannot often be dismantled and rebuilt entirely anew as can be done with an out-of-date building. They have to be overhauled, and the alterations which are practicable are those which can be put into effect while in some respects maintaining " business as usual ".

There are many methods of selling, but this study only deals with that aspect of auction selling where farmers take upon themselves some measure of responsibility and control over the auction selling facilities in particular areas. Selling by auction does not always imply that the selling is better or more economically done than by other methods. Auctions may be a curse or a blessing from the farmers' point of view. They may be bad, not because the principle of selling by auction is in any way wrong, but because there may be too many auction marts, some or all of which are badly equipped, badly managed and insufficiently advertised. The auctioneer has two ways of augmenting his income—firstly by increasing his turnover as much as possible in a few auctions, or secondly by establishing new auctions in as many areas as possible. The latter is the method usually adopted. It is better business for the auctioneer to have several scattered marts, however badly they function, than one large mart equal in turnover to a larger number. The small marts provide contacts and clients over a wide area, and from this grows another part of the auctioneers' business such as farm sales, valuations, property sales, etc.

From the farmers' point of view there are no worse conditions of selling than prevail in small auction marts which are dominated and controlled by a few local buyers, and where no effort is made by those responsible for providing marts to improve selling facilities, equipment and advertisement.

On the other hand, large auction marts properly equipped and operated can be satisfactory to farmers in general. Inefficient and haphazard methods of applying the principle of auction selling are responsible for a considerable financial loss to Welsh farmers, and as long as the organisation of auction selling is carried on without reference to the opinions and requirements of farmers, conditions are likely to remain extremely unsatisfactory.

Farmers themselves can do much to re-establish auction selling on satisfactory lines by taking upon themselves some part of the responsibility of re-organising auction selling

and securing for themselves some measure of control over the system. It is not suggested that all marts in Wales are operated for the single purpose of providing income for auctioneers and a monopoly to local buyers of livestock. Many auctioneers have given serious consideration to the needs of farmers in their areas and are doing all they can to meet requirements.

In some areas in which activities in selling livestock were inadequate or unsatisfactory farmers have organised to supply for themselves additional or more satisfactory services. This is not the only method of improving conditions, for in some cases improvements are obtained by making suggestions or exerting pressure upon the owners or operators of privately owned marts. or by arrangement with authorities which control public markets. But the following notes on the methods of operation, results, and experiences of livestock marts which are wholly or partly controlled or supervised by farmers may prove of some usefulness to those farmers who may find it necessary to organise themselves for the purpose of auction selling.

Co-operative marts.

There are seventeen livestock marts in Wales wherein farmers exercise some amount of direct control. They differ appreciably from one another in the methods which were adopted for their establishment and in their present methods of conducting business. Six out of these seventeen marts are registered as co-operative societies, and these are similar in that their formation and structure have been subject to the regulations of the Industrial and Provident Societies Acts. In the extent to which they control selling and in the arrangements made with auctioneers they differ considerably. In four out of the six societies income is derived from a proportion of the commission charged by the auctioneer. The proportion varies from half the total commission, as at Devil's Bridge, to one-sixth of the commission as at Kidwelly. The proportion of commission retained by auctioneers depends on the apportionment of duties performed by them and the duties performed by management committees of societies, and the variations in the arrangements made with auctioneers are shown in the reports on individual marts.

Two of the co-operative societies have subscribed the capital necessary for the establishment and equipment of marts in which the selling rights are let to auctioneers at a fixed annual rental. At these marts the auctioneers conduct and control their businesses entirely as a private concern.

Limited Liability Companies.

Six marts are owned or leased by limited liability companies in which the shareholders are chiefly farmers, but persons other than farmers hold shares and seats on boards of directors. In these cases the auctioneers conducting sales are usually shareholders, but this condition is not universal. In one or two cases the mart may be entirely controlled by a management committee and a paid staff, and in such cases auctioneers have no other function than that of selling and are engaged at a daily fee or at an annual salary. At Ruthin and Llandilo the companies conduct their own business entirely, paying the auctioneer an annual fixed salary for selling only. At Llanrhaiadr and St. Clears companies have been formed to establish and equip marts which are let to auctioneers at annual rentals. At Newport (Mon.), a company has been formed to lease a mart, sections of which are let at annual rentals to three firms of auctioneers. At Presteign the mart is in the possession of a limited company, but selling rights are let at an annual rental to one firm of auctioneers. In these cases farmers have little control over selling arrangements.

Miscellaneous organisations.

Four marts have been established through the activities of voluntary committees of farmers. These committees have organised and collected funds by means of subscriptions for the purpose of acquiring or renting ground and erecting a mart, or have been granted land in trust by local landowners for the purposes of marketing. At Sennybridge and Whitland the marts are rented to auctioneers at a fixed annual rental, the committee undertaking to provide for cleaning, repairs, rates, etc. At Sennybridge the auctioneer takes the full commission charged. At Whitland an agreement is made with the auctioneer to charge a commission of 3d. per £ to subscribers and 4d. to non-subscribers. The additional 1d. charge to non-subscribers going to the committee. At Rhayader the mart is rented to a firm of auctioneers which has complete control of selling arrangements.

At Goginan a voluntary committee has erected a small mart. Out of the total commission of 4d. charged, 3d. is taken by the auctioneer and 1d. by the committee. The committee is responsible for the maintenance and repairs of the mart and payment of rates, etc. Selling and the conduct of the mart is entirely in the hands of the auctioneers.

There is a small mart held at Pontardulais on ground belonging to the Pontardulais and District Farmers' Association, Ltd.,

which is a requisite Society. Beyond letting a plot of ground to a firm of auctioneers the Society has no connection whatsoever with the operation of the mart which is entirely in the hands of the auctioneer.

The figures in Tables I and II provide some information relating to the time of establishment, and the financial position of most of these organisations at the end of 1929.

TABLE I.

Membership and Capital of Farmers' Marts in Wales, 1929.

	Established.	*No. of Members or Shareholders.*	*Share Capital.*	*Balance of Profit + or Loss —. Dec. 31, 1929.*
			£	£ s. d.
CO-OPERATIVE FARMERS' MARTS.				
Talybont (Cards.)	1926	86	86	— 27 18 8
Talybont (Brecon)	1920	186	1,723	+ 200 5 0½
Kidwelly ...	1921	160	301	+ 213 18 2
Tregaron ...	1929	200	(Established Dec., 1929).	
Nelson ...	1922	38	1,075	+ 106 10 8
Devil's Bridge ...	1920	121	440	+ 22 17 10
LIMITED LIABILITY COMPANIES.				
Ruthin* ...	1920	190	5,062	+ 478 2 11
Llandilo Bridge ...	1906	150	2,976	+ 621 11 0
St. Clears ...	1922		1,500	
Llanrhaiadr ...	1906	118	568	+ 446 4 3
Newport (Mon.) ...	1923	(Private company. Accounts not available).		
Presteign ...	1923	(No data available).		
COMMITTEES, ETC.				
Sennybridge ...	1906	500	2,750	— 184 11 1
Goginan ...	1926		30	+ 2 15 0
Whitland ...	1919		2,000	
Rhayader ...		(No data available).		

* 31st December, 1927

TABLE II.

Number of livestock offered at Marts partly or wholly under farmers' contral.

Total Entries 1927 or 1928.

Mart.	*Frequency.*	*Cattle.*	*Calves.*	*Sheep.*	*Pigs.*	*Total.*
BRECON.						
Sennybridge & Dist. Voluntary Stock Market Committee	Weekly.	500	550	17,000	600	18,650
Talybont and District Farmers' Markets Association, Ltd. ...	Weekly.	450	360	9,000	1,000	10,810
CARDIGAN.						
Devil's Bridge Auction Mart, Ltd. ...	Monthly.	500	—	12,000	10	12,510
Talybont Farmers' Mart, Ltd. ...	Periodically.	300	—	5,000	10	5,310
Goginan Farmers' Mart ...	Monthly.	80	—	2,570	—	2,650
Tregaron Farmers' Mart ...	Monthly.	—	—	—	—	—
CARMARTHEN.						
Llandilo and District Cattle Markets and A. M. Co., Ltd. ...	Fortnightly.	2,470	1,600	14,500	7,480	26,050
Whitland Market Committee ...	Fortnightly.	3,200	3,000	10,000	8,000	24,200
St. Clears Market Co., Ltd. ...	Fortnightly.	1,860	1,220	3,550	1,110	7,740
Kidwelly and District Farmers' Mart, Ltd.	Fortnightly.	750	400	1,020	1,600	3,770
Pontardulais & Dist. Farmers' Assn.,Ltd.	Monthly.	200	130	650	750	1,630
DENBIGHSHIRE.						
Llanrhaiadr & Dist. Smithfield Co., Ltd.	Fortnightly.	300	20	29,710	240	30,270
Ruthin Farmers' Auction Co., Ltd. ...	Fortnightly.	2,250	—	18,500	8,750	29,500
GLAMORGAN.						
Nelson & District Farmers' Assn.,Ltd.	Fortnightly.	670	930	8,000	1,770	11,370
Pyle & Dist. Agric. Co-op. Society* ...	Monthly.	100	30	520	30	680
MONMOUTH.						
Newport Market Co., Ltd. ...	Weekly.	5,517	2,840	16,159	9,721	34,237
RADNOR.						
Presteign Auction Co., Ltd. ...	Once or twice monthly.	3,000	200	6,000	800	10,000
Rhayader Marts Committee ...	Fortnightly.	460	20	12,620	20	13,120

* Discontinued.

CO-OPERATIVE SOCIETIES.

Cardiganshire.

Devil's Bridge Auction Mart, Limited.

Registered July 17, 1920, as a Co-operative Society. Number of shareholders, 124. Share capital, £440, in £1 shares fully paid up.

Turnover.

Year.	*Sheep.*	*Cattle.*	*Pigs.*	*Receipts.*
				£ s. d.
1928	9,572	317	13	14,456 9 0
1929	9,803	275	2	15,829 2 6

SUMMARY OF EXPENDITURE AND INCOME, 1929.

Expenditure.	£	s.	d.	*Income.*	£	s.	d.
Auctioneers' commission	132	5	1	Commission ...	264	9	5
Operating expenses ...	88	11	1	Tolls ...	40	14	4
Depreciation ...	67	0	0	Interest ...	0	6	0
Profit balance ...	17	13	7				
	£305	9	9		£305	9	9

Accumulated Surplus, £256 2s. 3d.

The depreciated value of buildings, etc., was estimated at £610 15s. 4d. on January 1, 1930, although paid up capital was only £440. There has been no borrowing of capital, but improvements have been made from time to time from a reserve fund. A dividend of 5 per cent. has been paid each year on share capital. Revenue is derived mainly from a commission charge of 4d. in the £ on all sales. Some income is derived from tolls, but this only amounts to about ½d. in the £ on total sales.

Auctioneers give their services in return for a commission of 2d. per £ on sales. Their duties consist of selling, keeping of accounts, and all secretarial work.

The Society has to meet all charges for porterage, wages, advertising and incidental sale expenses. Bad debts have also to be borne by the Society, but the total losses through bad debts have only been approximately £6 during the whole period of operation.

No provision is made for insurance of any kind. Auctioneers accept no liability. Any losses due to accidents prior to sale fall on the vendor, and any losses subsequent to knocking down to a buyer fall on the buyer. Redress for fraudulent description or the presence of a disease not distinguishable by

inspection in the selling ring can only be obtained through arrangement between buyer and seller or by legal action.

This mart is almost entirely used for the sale of store stock, mainly sheep. Consequently a heavy capital expenditure on equipment and layout has not been necessary. The mart is successful and expanding its business and attracts buyers very well. Sheep sales are seasonal. This mart, in an isolated area otherwise poorly served, has met the requirements of farmers in the locality.

Talybont Farmers' Mart, Ltd.

Registered as a Co-operative Society, 1926.

Capital.

Subscribed by members (to 1929)	£86	0	0
Bank overdraft	44	4	11
Valuation of ground, fixtures, etc.	75	6	10

Commission.—4d. in the £.

Auctioneers charge 3d. in the £.

Society's share of Commission, 1d. in the £.

SUMMARY OF EXPENDITURE AND INCOME, 1929.

Expenditure.	£	s.	d.	*Income.*	£	s.	d.
Commission paid ...	78	19	9	Commission received ...	105	6	2
Operating expenses ...	43	5	9	Tolls ...	12	14	9
Depreciation ...	8	7	6	Rents ...	8	11	0
				Balance (loss) ...	4	1	1
	£130	13	0		£130	13	0

Trading Loss, 1928 ...	£23	17	7
Trading Loss, 1929 ...	4	1	1

This is a small mart, which is not well equipped, holding monthly sales. The district had no mart and at present has only a poor mart service. Farmers desired more and better service, but the development of small marts in the area tends to split up consignments of stock. There is still much selling on the farms to dealers for which the small marts do not provide a really efficient substitute.

Tregaron Farmers' Mart, Ltd.

Formed December, 1929. Registered as a co-operative society. Nominal capital, £200. Shares issued, 200 of £1 each: 5s. paid on allotment. Subscribed capital, £50. Membership, 200. *Mart ground*: Rented from Town Council. *Tolls*: These are collected and taken by the Town Council. A commission of 4d. per £ is charged on all stock. *Selling*: Two firms of auctioneers were appointed as joint salesmen. Auctioneers charge 3d.

in the £, for which they provide labour, porterage, advertisements and keep accounts and are responsible for bad debts. The Society retains 1d. in the £ to be used for improvements, etc.

Carmarthenshire.

Kidwelly and District Farmers' Mart, Ltd.

Established in 1921 as a co-operative society and registered under the Industrial and Provident Societies Acts. Subscribed capital, December 31, 1929, £301. Number of shareholders. 160. The mart is the freehold property of the Society, and was valued at £360 December 31, 1929.

The Society's income is derived from a part of the auctioneer's commission, tolls, and interest on War Loan investments.

SUMMARY OF EXPENDITURE AND INCOME, 1929.

Expenditure.	£	s.	d.	*Income.*	£	s.	d.
Operating expenses ...	28	16	10	Commission and tolls ...	48	3	8
Affiliation fee ...	2	0	0	Investment interest ...	5	0	0
Charges *re* investments ...	1	1	0				
Balance (profit) ...	21	5	10				
	£53	3	8		£53	3	8

Accumulated Surplus, £213 18s. 2d.

Selling arrangements, etc. Auctioneers receive 2½d. per £ on sales, and an additional £5 per annum for collecting tolls. Their duties consist of selling, provision of necessary labour, and keeping accounts. They are also responsible for bad debts. The Society receives ½d. per £ of sales commission and tolls, less collecting charges.

This Society has provided good service since its establishment. A dividend is not paid, profits being used for improving the mart or invested to yield income. The Society holds an annual Christmas fat stock show. The show expenses amount to about £30 per annum, and are provided for by subscription and gate receipts. The Society is in a strong financial position. A total surplus balance of £213 18s. 2d. was shown at December 31, 1929.

Glamorganshire.

Nelson and District Farmers' Marts Association, Ltd.

Established 1922, as a co-operative society under the Industrial and Provident Societies Acts. Share capital, £1,075 in £1 shares fully paid. Number of shareholders. thirty-eight. Leasehold ground, twenty-one years, annual ground rent of £4.

Depreciated value of Mart, 31st December, 1929	...	£879 6 0
Fittings	...	198 0 0
Total		£1,077 6 0

SUMMARY OF EXPENDITURE AND INCOME, 1929.

Expenditure.	£ s. d.	*Income.*	£ s. d.
Operating expenses ...	44 16 4	Auctioneers' rental ...	125 0 0
Depreciation ...	44 11 0		
Repairs ...	29 5 0		
Balance ...	6 7 8		
	£125 0 0		£125 0 0

Accumulated Surplus, £106 10s. 8d.

Commission is 3d. in the £ all round.

This Society has made profits in the past, and had a balance of profits in hand of about £154 at the end of 1928. It paid interest to the amount of nearly £54 in 1929, and as a result of very small profits in that year its balance of profits in hand was reduced to £106. The total assets are now valued at £1,191, against shares of £1,075.

This is a small mart, in which the buyers are chiefly butchers. The number of buyers is insufficient; the mart is not making progress, and is barely holding its position. It was formed for the convenience of farmers, and has served their purposes, but any influence they exercise on conditions of selling is indirect rather than direct.

Breconshire.

Talybont and District Farmers' Markets Association, Ltd.

Established 1920 and registered under the Industrial and Provident Societies Acts.

Share Capital, £1,723 in £1 shares fully paid. Land and buildings are the property of the Society and stand in the accounts at £1,874 10s. 10d. This valuation, however, has been carried forward from year to year at the same figure—no provision having been made for depreciation. Repairs have been carried out when necessary from time to time. From 1930 provision will be made for depreciation. So far members have preferred to take a dividend rather than to provide for depreciation. No tolls are charged.

Selling rights at the mart are let to a firm of auctioneers for a fixed annual rental of £100. Additional income is derived from rents of house and advertisement space and tolls for the use of weighbridge. The auctioneer is responsible for all selling

expenses and has full control of sales. The Society is responsible for cleaning the mart, the payment of rates, taxes and insurance, for repairs and for all secretarial work in connection with the affairs of the Society.

SUMMARY OF EXPENDITURE AND INCOME, 1929.

Expenditure.	£ s. d.	*Income.*	£ s. d.
Operating expenses ...	84 9 6	Auctioneers' rent ...	100 0 0
Balance (profit) ...	38 5 8	Rents ...	20 16 0
		Tolls ...	1 19 2
	£122 15 2		£122 15 2

Accumulated Surplus, £200 5s. 0½d.

This Society is in a sound position. Dividend has been paid each year, and an accumulated reserve balance of over £200 was carried forward from last year's accounts.

The amount of business carried on at this mart is increasing and various improvements are projected. It provides good service to farmers who always are able to select their own salesmen and to adapt the mart and its facilities to their own convenience. Farmers take an active interest in the work of the Committee. The auctioneer is an influential member of the Society.

LIMITED LIABILITY COMPANIES.

Carmarthenshire.

The Llandilo and District Cattle Market Auction Mart Co., Ltd.

Formed in 1906 as a Limited Liability Company with an Authorised Capital of £3,000 in £1 shares, and Issued Capital £2,976 made up as follows :—

Actual shares subscribed for	£1,488
Bonus shares issued	£1,488
Issued capital	£2,976

Number of shareholders, 150. Capital value of mart, December, 1929, £2,509 14s. 4d. War Loan, 1929-47 at cost, £411 11s. 0d. Turnover, 1929, £79,318 11s. 10d.

SUMMARY OF EXPENDITURE AND INCOME, 1929.

Expenditure.	£ s. d.	*Income.*	£ s. d.
Operating expenses ...	905 12 2	Commission ...	1,036 11 4
Balance (profit) ...	328 2 8	Tolls ...	139 9 5
		Interest on investment	20 8 7
		Other receipts ...	37 5 6
	£1,233 14 10		£1,233 14 10

Accumulated Surplus, £1,671 11s. 0d.

Tolls. Cattle, 3d.; cows and calves, 6d.; pigs and sheep, 1d.; calves, 3d.

Auctioneers' fees, £2 2s. 0d. per day for selling only.

The mart has been profitable and the financial policy of the Company has been of a conservative character. The mart is generally regarded as serviceable. Expenditure on the mart itself has not been heavy, for the original capital was less than £1.500. During 1929, when sales amounted to over £79,000, the value of the mart buildings, etc., was estimated at about £2,500.

The auctioneers are the chief shareholders, but the Chairman of the Company is a local landowner and farmer and some, at least, of the directors are farmers, so that farmers' interests in the arrangements of the mart get full consideration.

St. Clears Market Co., Ltd.

A Limited Liability Company was floated to buy freehold land for the purpose of a market ground, with a capital subscription of £1,500 in £1 shares fully paid. Subscribers are mainly local business men, including a minority of farmers. Auctioneering rights are granted to Messrs. Lloyd and Thomas, Carmarthen, who are allowed to hold sales at fortnightly intervals at a rental of £75 per annum. This firm conducts and controls the conditions of its own sales. When special sales are held the Auctioneers pay an agreed extra charge.

Pleasure fairs and other functions are held on the ground and yield an additional income. Other income of the Company is derived from tolls charged at the following rates :—

Beasts	...	3d.
Cow and Calf		5d.
Pigs	...	2d.
Sheep	...	1d.
Calves	...	2d.

Tolls are collected by the Secretary of the Company. Auctioneers' commission charges are :—

On lots sold for £5 or over, 3d. in the £ for all types of stock. For entries selling for less than £5 the commission is 1s. 4d. per lot.

This mart is gradually declining as the business is going to Carmarthen, which is considered the best market in South Wales.

Denbighshire.

Ruthin Farmers' Auction Company, Limited.

Public Limited Liability Company. Formed 1920; Nominal Capital, £10,000; Issued Capital, 6,808 Shares of £1 each, 15s.

paid up; £5,062 5s. 0d. Number of shareholders (1927), 190. Average holding per member, £35 16s. 2d. Formation expenses, £600.

At formation, one auctioneers' and valuers' business, including goodwill, was purchased at £4,000. Another auctioneer's business and premises were leased at a rental of £135 per annum for a period of three years, lease renewable at the end of this period. During the continuance of the lease an agreement was made with the previous owner to supply the services of one auctioneer and canvasser at £500 per annum, and the services of a second auctioneer when required at £3 3s. 0d. per day.

One mart is reserved for fat stock and one for store stock.

Sales are held fortnightly on the same day at both marts, but special sales of store stock are held periodically.

Turnover (1927)	£100,862	2	1
Gross Income (1927)	1,807	1	4
Operating costs	1,716	13	0
Profits (1927)	90	8	4

SUMMARY OF EXPENDITURE AND INCOME, 1927.

Expenditure.	£	s.	d.	*Income.*	£	s.	d.
Operating expenses ...	1,716	13	0	Commission on Marts ...	1,708	17	6
Balance (profit) ...	90	8	4	Farms and furniture ...	85	0	6
				Surplus account ...	13	3	4
	£1,807	1	4		£1,807	1	4

Accumulated Surplus, £478 2s. 11d.

Trading Results.

1921	Profits	...	£160
1922	Loss	...	278
1923	Profits	...	103
1924	,,	...	418
1925	,,	...	438
1926	,,	...	387
1927	,,	...	90

Business organisation. This is a self-contained business carrying on public auctions, farm sales, valuations, etc. A secretary and office staff are maintained and salesmen operate under contract. The commission charge for all classes of stock is 4d. in the £. No scheme of insurance is in operation and the company accept no liability. Claims have to be settled between buyer and seller or through Court action.

The business is situated in an exceptionally good centre in the Clwyd Valley. The company is rather severely handicapped as a result of the high cost of acquiring one business and leasing

another, and high formation costs. Had this company been registered under the Industrial and Provident Societies Acts, the formation expenses would have been considerably reduced.

The service of the mart represents an improvement on the general services of marts in North Wales, especially westwards of Ruthin.

The Llanrhaiadr-Mochnant and District Smithfield Co., Ltd.

Limited Liability Company, formed in 1906. Nominal Capital £1,000 in £1 shares. Issued Capital, 568 shares fully paid. Number of shareholders, 118.

SUMMARY OF EXPENDITURE AND INCOME, 1929.

Expenditure.	£	s.	d.	*Income.*	£	s.	d.
Operating expenses ...	112	8	9	Tolls: Vendors ...	116	8	10
Depreciation ...	20	5	0	,, Auctioneers ...	60	16	2
Profit balance ...	65	11	3	Investment interest ...	17	0	0
				Rent ...	4	0	0
	£198	5	0		£198	5	0

Accumulated Surplus, £446 4s. 3d.

Depreciated value of Mart, £866 4s. 0d.

The shareholders of this Company consist mainly of farmers. The auctioneer is also a shareholder. All the directors are farmers. The Company is responsible for the maintenance, repairs, and the cleaning of the mart and all accounts and secretarial work connected with this.

The auctioneer pays no rent for the mart, but pays a toll of 1d. per head for cattle and ½d. per head for sheep sold. He is entirely responsible for the conducting of the mart and bears all his own selling costs.

Vendors pay a toll of 2d. per head for cattle and 1d. per head or 1s. 6d. per score for sheep.

The auctioneer charges a commission of 4d. per £ on sales.

Most of the cattle from the area are sold at Oswestry mart. Sheep offered at Llanrhaiadr are smaller than at Oswestry and attract special buyers, and sales consist mainly of sheep. The mart is in a sound financial position, and throughout its period of operation has given satisfactory service to farmers. The terms of the arrangement between the Company and the auctioneer provide that the latter shall submit his sale fixtures and operating methods to the Directors for approval, and in this way the Company exercises a good deal of control over the operation of the mart.

Monmouthshire.

Newport (Mon.), Cattle Market Co., Ltd.

This is a private limited company formed in 1923. Shareholders consist of members of the N.F.U. and the Butchers' Association. The farmers are represented by six directors and the butchers by four.

Previous to the formation of the Company the market at Newport was owned by the Tredegar Estate. After formation the Company took over the market fully equipped on a lease of twenty-one years together with the toll rights.

The Company lets the selling rights at annual rentals to three different firms of auctioneers, and the rents received from these sources, together with the market tolls, constitute the income of the Company. The accounts of the Company have not been available for analysis.

Radnorshire.

Presteign (Radnorshire) Auction Co., Ltd.

The mart at Presteign is owned by a Limited Company whose shareholders consist mainly of farmers together with some local tradespeople. Most of the Directors are well known farmers who exercise a considerable amount of control over the operation of the mart. Accounts have not been available for inclusion in this report. Selling rights in the mart are let at an annual rental to a single firm of auctioneers.

MISCELLANEOUS COMMITTEES, ETC.

Carmarthenshire.

Whitland Market Committee.

The Yelverton Estate handed over ground intended as a market area to twelve trustees. In 1919 the trustees formed a committee of eighteen members. Farmers in the locality were asked to subscribe to a fund of £2,000 for the development of the market. This sum was duly subscribed and expended on laying out the mart and providing equipment. On completion the mart was leased at an annual rental to Messrs. Davies and Lloyd, Carmarthen. Only cattle, sheep, and calves are sold in the mart. Pigs are sold in a field adjoining.

Tolls are charged at the following rates :—

Beasts ...	3d.
Cow and Calf	5d.
Pigs ...	2d.
Sheep ...	1d.
Calves ...	2d.

These, together with the rent of the mart, furnish the income of the committee.

The ground is let for other purposes when opportunities arise. A produce market, which earns additional income through tollage, is held there each Friday. Subscribers to the establishment capital are charged 3d. in the £ commission. Non-subscribers are charged 4d. in the £. The mart is a private business concern and livestock sales and their conduct are entirely controlled by private auctioneers.

Pontardulais and District Farmers' Association, Ltd.

The Pontardulais Co-operative Society (a requisites business) owns the land on which the mart is held. No equipment is provided on the ground. A firm of auctioneers rent the ground at 5/- per month, supplying their own pens, etc., and conducting their own mart entirely. No tolls are charged. Commission is charged at the rate of 3d. in the £. Sales are very small.

Glamorganshire.

Pyle and District Agricultural Co-operative Society.

A private mart was held at Pyle by a local auctioneer, until about eighteen months ago, on ground adjoining the Pyle and District Agricultural Co-operative Society, but not belonging to the Society. The weighbridge of the Co-operative was used, but that was the only contact.

The mart was a small one and had declined to small proportions. It was finally discontinued at the beginning of 1929, and Bridgend now serves as the market centre for the area.

Cardiganshire.

Coginan Farmers Mart.

The mart was established in 1926 by a voluntary committee. The members of this committee are elected annually at a general meeting, and, with one or two exceptions, they consist of farmers.

Much of the work in adapting the ground for the purposes of a mart was provided voluntarily and a fund of £30 was realised from a collection.

The ground is rented at £4 per annum.

1929.	Income	£15 17 2
	Expenses	14 11 6
	Profits	£ 1 5 8

A reserve balance was carried forward from 1928 of £13 3s. 6d., making a total reserve of £14 9s. 2d.

Improvements expenditure during 1929 amounted to £11 14s. 2d., leaving a reserve balance of £2 15s. at the end of the year.

A commission of 4d. per £ is charged by the auctioneer, who retains 3d. per £ commission and provides the following services : selling, porterage, and responsibility for bad debts.

The Committee receive 1d. per £ commission and tolls, and is responsible for any labour necessary for repairs, etc., and for any expenses incurred in advertising. Total sales, 1929, £2 226. Sales are irregular, held at arranged intervals.

This mart is controlled by farmers to the extent that the committee is responsible for its layout and equipment. The committee can also appoint their own auctioneers, but the actual selling is in the hands of the auctioneers. The mart is not registered as a Co-operative Society or as a limited liability company. The area in which it operates is not a good one and prospects for developing the business are not very good. The mart, however, serves a local need, and so far has given a satisfactory service.

Breconshire.

Sennybridge and District Voluntary Stock Market Committee.

A voluntary committee of farmers was formed in 1908 for the purpose of establishing a livestock market at Sennybridge. Ground was given free by the Abercamlas Estate for the purposes of a market. Farmers were asked to make donations to a fund to be used for the erection of a mart on the ground. Subscriptions were received in large and small amounts and accepted as free-will offerings. Appeals for funds have been made at various times and up to the present about five hundred subscriptions have been received, making a total of £2,750. The land on which the mart is situated is vested in ten parishes and the District Councillors for these parishes function as trustees.

Subscribers to the Mart Fund are represented by a management committee of sixteen members. Up to the present about £8,000 has been expended on the mart for erection, improvements, and repairs.

The committee is responsible for keeping the mart in repair, providing necessary improvements and the cleaning after sales. Selling rights at the mart are let to an auctioneer at an annual rental of £80. Additional income is derived from tolls, which amounted to £64 in 1929. The income of the committee is derived from the auctioneers' payment for selling rights and from tolls.

Recent improvements of the mart were financed by means of a bank overdraft, and each year's profits are allocated to the reduction of the loan.

Income (1929)	...	£145 2 5
Expenditure	...	70 17 11
Balance	...	£ 74 4 6

If the average profits remain the same, the outstanding overdraft can be wiped out during the next three years. This committee has been instrumental in providing a good mart where no market was previously held. It serves an important producing area and its turnover is increasing annually. There is a difficulty in securing fair-sized sales of livestock from January to May. Both supplies and buyers are scarce during this period, but there are good supplies from June to December and buyers are plentiful.

Radnorshire.

Rhayader Mart Committee.

A local landowner has presented land for the purposes of a mart, which is vested in appointed trustees. The committee has equipped the mart for the purpose of conducting sales, and has let the selling rights to a firm of auctioneers. The mart area is used for the purposes of holding monthly fairs in addition to the auction sales arranged by the auctioneer. Tolls are charged for animals entered into fairs, but the auctioneer has bought the toll rights in respect of his own sales. Animals therefore enter the auction sales toll free, and a commission charge of 3d. per £ on sales is made.

Conclusion.

The experiences of the various types of organisations summarised above indicate some of the weaknesses and advantages of different arrangements.

The most successful form of organisation is that where a society or company of farmers and tradesmen control the mart completely. The operations of the organisation are directed by management committees or boards of directors together with a paid secretary responsible for current business arrangements, accounts, and finances. Such organisations retain complete control over the whole business, and pay auctioneers for selling at agreed fees per day or under contract for a period of time.

Those organisations, whether co-operative societies or farmers' public companies or local committees, which have accumulated capital and invested it in purchasing land and equipping marts appear to be selling their own birthright when they hand over the entire selling rights to an auctioneer on a basis of rental or part commission. On the basis of part commission, one small society with a turnover of about £6,000 pays an auctioneer an average of between £7 and £8 per day for selling only for two or three hours; whereas another company which controls its business receives the services of an auctioneer for a heavy day's work for a fixed fee of £2 2s.

From the point of view of finances and control the most satisfactory plan for a farmers' mart appears to be the placing of the entire management and control in the hands of a management committee employing a secretary, who may be an auctioneer, and paying their salesman a fixed fee per day for selling. There is nothing difficult or complex attached to the simple function of eliciting and registering bids for livestock in a sale ring. The work could be done almost by any man with business training and aptitude, and who holds an auctioneer's licence.

There is no doubt that auction marts still have a large part to play in the primary marketing of livestock in Wales. When organised on a sufficiently large scale, well equipped and conducted, they provide better facilities for selling than the private treaty markets, and usually give better results than are obtainable by selling on the farm. The advantages they offer are more than equal to the costs of equipment and operation. It is, therefore, surprising that some of the enterprises described have shown so little sign of progressive development. Some of the enterprises show little, if any, advance on conditions in privately owned markets, while in other cases the local farmers take pride in the facilities they have secured and appreciate the services they obtain from their own organisations.

TYPES OF WOOL USED IN WOOLLEN FACTORIES IN WALES.

By H. Maldwyn Williams,
Textile Industries Advisor, University of Wales.

Since the days when the woollen mills of Wales were founded to manufacture the native wool of their localities many changes have taken place. The early mills represented a simple but important development of the system of manufacture for

domestic purposes. The home loom was used only part time, the weaver was not a specialist and the spinning was done at odd moments. Then one or more persons specialised in weaving and a loom or looms were continuously at work, except possibly during the harvest season. This was technically the " domestic " system of industrial organisation, because it was carried on in the homes of the workers and not because it was carried on to supply the needs of the sole family. In the early stages of this commercial development the specialisation was local : the weavers manufactured the wool of their farmer neighbours, often for the use of the farm families. But in many parts the supply of wool was in excess of local requirements, and either wool or cloth had to be sold to other areas. Much wool was sold, but trade in woollen goods increased. Then gradually the flannel trade and manufacture was concentrated in larger factories which still used local wool.

The main supplies of raw material came from sheep of the Welsh mountain type or a Welsh cross-bred. This wool was admirably suited to the making of rough cloths, for it was open in staple and could be easily carded and spun with the primitive machinery at the disposal of the manufacturer. Even to-day the art of carding is not thoroughly understood in Wales, and it is only in the larger mills, with modern machinery, that Colonial wools can be utilised successfully. Welsh wool, also, has not the same tendency to shrink as some other wools, and this is a valuable property. Flannel and other cloth made from wool of the Welsh mountain type is almost unshrinkable. It was upon this property that the success and reputation of the Welsh flannel industry arose and for a long time depended.

But manufacturing and commercial changes have altered the situation and the more stable of the factories now represent a part of the general commercial organisation of the textile trade. While local materials are used, it is both in competition and in conjuction with supplies from other sources.

There has been a marked decline in the use of locally grown wools in Wales during the last decade. Some of the reasons for this decline may be summarised as follows :—

1. The increasing demand for finer cloths, necessitating the use of finer wools.
2. The presence of kemp and coloured hairs in the fleece. As most of the manufactured materials are white (blankets, etc.), or have white grounds, it is important that the wool used should be free from all coloured fibres and impurities such as tar stains, vegetable matter, etc.

3. Lack of attention given to the fleece by Welsh farmers, and consequently the necessity of the manufacturer giving more attention to the wool during manufacturing processes. He has to cut away the britch and remove all foreign impurities. It is quite a common occurrence to find, when the fleece is opened, all the floor sweepings of the shearing shed enclosed.

Welsh cross-bred wool would be very suitable for the manufacture of many types of cloths in Wales, if the kemp and coloured fibres were eliminated from the fleece. Only in a few instances, e.g., a rough " sports " tweed, is the kemp desirable in the wool.

The pure Welsh fleece is used only in a few districts, mainly Denbighshire and the uplands of Cardiganshire. Most wool grown in the neighbourhood of the factories, especially of South Wales, consists of Welsh crossed with Shropshire, Suffolk, Kerry, South Down, Ryeland, and Cheviot.

When the manufacturer gets a supply of wool each fleece is sorted into four grades :—Firsts, Seconds, Thirds, and Britch. The last is sold to Yorkshire wool agents. *Firsts* consists of the finer parts of the fleece, wool of good colour, suitable for using as white for flannels, blankets, and knitting yarns. *Seconds* is used for dyeing to supply coloured yarns in flannels and tweeds. *Thirds* is only used for blending with the above qualities or with cotton for the production of low-grade flannels, and in the manufacture of counterpanes, etc.

Wools purchased outside the areas of the factories and outside Wales include both Home and Foreign. Home wools of the Suffolk, South Down, and Dorset breeds are employed for the finer grades of flannels, blankets and tweeds. Some of this may be used without any previous sorting, although it may be " picked " to remove foreign matter, etc.

Colonial supplies of fleece and skin wools are only used when a very fine wool is required for the manufacture of the finest flannels and for blending with cotton in the production of union flannels.

Good quality " waste " is used but to a small extent, although it is very suitable for blending with Welsh wool in the making of blankets. It adds loftiness and bulkiness to the thread and therefore a fullness of handle to the fabric.

Tweed manufacture.

No fine tweeds are made in Wales, only rough tweeds for farmers and sports wear. For these materials, " cross-breds "

can be used; and being dyed no particular attention need be paid to the whiteness of the staple. In some cases the presence of kemp is of advantage, adding a certain character to the fabric. For the production of grey cloths, all kempy wool is avoided, as the kemp fibres do not dye and do not blend with the wool itself, but bristle through the material, making an unsightly surface.

It is a common practice when using wool of First and Second qualities to dye only the Seconds—which may contain coloured fibres—and any white wool introduced will be Firsts. That is to say, light and mid-brown blends would be made by using the same dyed wool (Second quality) and blending with different proportions of white (First quality). For example:

Mid-brown: 30 per cent. dark brown and 70 per cent. white.
Light brown: 50 per cent. dark brown and 50 per cent. white.

In the same way a range of greys is produced by blending white with black or navy blue, the proportions varying from 10 per cent. to 90 per cent. white.

Blankets.

For the manufacture of blanket material only the whitest wools are used. Of the Home wools, fleeces are chosen with the longest fibres. This wool may then be blended with another wool of short fibre length to give bulkiness to the thread. Moreover, if the blanket is "raised", the short fibres gave a more satisfactory "nap" than do the longer fibres. The long fibres serve to bind the thread together, and the shorter fibres, besides giving bulk to the thread, also assist the milling of the material by their readiness to shrink and felt during the process of finishing. The wools used to introduce short fibres are New Zealand slipes or skin wools, and good quality waste. These blends are made up thus:

(*a*) 70 per cent. South Down and 30 per cent. N.Z. skin wool.
(*b*) 80 per cent. Shropshire and 20 per cent. waste.

Most Colonial wools are unsuitable for use in white goods, owing to the presence of vegetable seeds and seed-pods (termed "burrs"), which are not easily removed in the carding process and seeds or fragments appear in the finished goods. These wools may, however, be purchased in the "carbonised" form, having been treated chemically to extract the vegetable matter.

Flannel.

This material is made in a number of grades. The best flannel is made for the Admiralty, using a Colonial wool of about 56's quality. The majority of manufacturers make flannel in

three qualities, First, Second, and Third, acording to the quality of wool employed. There are also the union flannels made of a mixture of wool and cotton.

First quality flannel is made from pure bred Home wools. This is used unsorted but is " picked " to remove pieces of tar, vegetable matter, etc. These flannels are made with white, cream, or fawn grounds. Darker colours for decorative purposes are introduced in slightly lower qualities of wool.

Second quality flannel is made from Welsh cross-bred wool, of medium length staple, and again any dyed wool introduced may be of lower quality than the white wool. Many of these flannels are made in dark shades, *e.g.*, Navy blues (using a cheap dyestuff), and so cross-bred wool of second quality can be used. These flannels are sold for colliers' shirtings.

Cotton mixtures.

Union, or Angola flannel is made in two styles :—

1. For the first cotton is blended with wool and mixed in the carding process. This necessitates using a wool which will blend with the cotton, *i.e.*, fine wool with medium length staple. These blends contain from 20 per cent. to 50 per cent. cotton.
2. For the second style cotton yarn forms the warp and a woollen yarn the weft of the piece. This material is produced more cheaply than an all-wool fabric, and the quality is dependent on the quality of the wool used in the weft. In a few cases, a cheap flannel is produced from a cotton warp crossed with a low-grade weft of Third quality Welsh cross-bred wool.

Counterpanes, Rugs, and Carpets.

These materials use up the lower qualities of wool and inferior cross-breds, of which only a small quantity is necessary for flannels. In these materials, softness of handle is not a desideratum, but the wool must be of a long staple and of strong fibres. The yarns which are used in the weaving of these fabrics are spun singly and then twisted together to make two- and three-ply yarns. The cloths are rough and coarse to the touch, but are very hard-wearing.

Quite small mills sometimes receive fleeces from local farmers, carry through the processes of manufacture, and return the finished product to the growers, but this system has almost disappeared. The manufacturer has to study the selling markets for his products and is obliged to secure raw materials which will

enable him to compete in type and quality of goods, and in price, with the manufacturers of other areas. He also is restricted as regards the types of wool used by the equipment of the factory, and the types of cloth that it will make. The factory equipment and the markets for manufactured products largely determine the types of wool which may be used. Although much of the equipment of Welsh factories was installed or has been used for dealing with native and sometimes local wool, the factories equipped only for this purpose have tended to disappear. In other cases the markets for the products of local wool have declined, and manufacturers have been obliged to seek other raw materials and sometimes to turn to the manufacture of different types of goods. The characteristics and qualities of the native wools of Wales, especially of the Welsh mountain type, remain much as they were, but in recent years these wools have found their markets for manufacturing purposes largely in other areas.

(*See* Shimmin: "The Production and Marketing of Wool in Wales. This *Journal*, Vol. IV, 1928.—EDITOR).

COMPARISON OF WASHED AND UNWASHED WELSH WOOL.

By PROFESSOR R. G. WHITE, M.Sc.,
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Opinions differ greatly as to the advantage or otherwise of washing wool before shearing. Probably the majority of lowland sheep are washed more or less thoroughly, and the advantages are obvious in the case of those sheep folded during the previous winter on arable land. In hill breeds there is a great difference. For instance, it is customary to wash Cheviot sheep, but not Blackfaces. In Wales there is no uniform policy. Some farmers always wash their sheep, others in the same district and on the same type of farm shear their sheep without washing.

It is difficult to say exactly what is the effect on price. If a buyer is asked to take unwashed fleeces from a farm where the bulk of the clip is washed, he expects a substantial allowance, varying from 10 per cent. to 25 per cent., for the greasy fleeces. On the other hand, the difference in value between whole clips of washed and unwashed wool is rarely as great as 20 per cent.

There are other questions, besides the price per lb., which enter into the matter. For instance, in some cases, where facilities for washing are not good, the cost of the operation may be

considerable. Even more important in the case of the mountain flocks is the delay which is necessary in order to allow the fleeces to become dry before shearing. Many mountain farms in Wales have very little enclosed land, and this is correspondingly valuable. The gathering of sheep from unenclosed mountain is an arduous, and often a lengthy, operation, which not only occupies the time of all the available staff, but disturbs the sheep and often leads to premature weaning of lambs. Therefore, once the sheep have been collected, an attempt is made to retain them in the enclosed land until they are dry enough for shearing. Given ideal conditions, twenty-four hours may be sufficient for this purpose, but in bad weather the period may be considerably longer. The keeping of the whole flock on the small amount of enclosed grazing available, for even three or four days, may be rather a serious matter for that particular farm.

On the other hand, it is more difficult to shear unwashed than washed Welsh sheep, and as the supply of skilled shearers is usually limited in proportion to the number of animals to be dealt with, anything which facilitates the operation is welcomed.

While the above considerations are sufficient to influence practice in some cases, there can be no doubt that in the great majority of cases the question of washing or not washing is decided by the farmer's view as to whether the financial returns from the wool will be greater or less. Although the matter can be put to the test in an obvious and simple way, there do not appear to have been any carefully controlled experiments on the matter,[1] and at the suggestion of Professor A. W. Ashby such a test was arranged during the summer of 1930. The plan of the test was arranged by the writers in consultation with Professor Ashby and Mr. J. A. Fraser Roberts. A grant in aid of the test was made by the Marketing Branch of the Ministry of Agriculture, and the co-operation of the City of Bradford Conditioning House was secured. Grateful acknowledgement must be made of the interest shown in the test by Mr. E. H. Townend, the Director of the Conditioning House, who gave every possible assistance.

It was decided to make the experiment as simple as possible, and, for the first year at any rate, to restrict it entirely to Welsh Mountain ewes, some on mountain farms on which they had been reared, others on lowland farms to which they had been taken nine or twenty-one months previously for the rearing of fat

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[1] Since this Report was prepared an interesting paper on "The Economy of Washing Kent Sheep before Shearing" has been published by N. L. Tinley in the *Journal of the Ministry of Agriculture* for May, 1931.

lambs. In no case had the sheep been folded on arable land, and in few, if any, cases had any artificial feeding been given. By the help of the respective County Agricultural Organisers, nineteen farms in North Wales were selected as follows :—

Anglesey 3.

No. of Centre.	
1	W. J. Thomas, Chwaen Goch, Llanerchymedd.
2	R. A. Lewis, Cwirtai, Ty Croes.
3	John Lewis, Cellar Farm, Ty Croes.

Caernarvonshire 6.

4	Madryn Farm School, Bodvean.
5	Edward Owen, Braich Saint, Criccieth.
14	J. Henry Jones, Tynymaes Farm, Bethesda.
18	D. E. Davies, Bertheos, Dolwyddelen.
19	R. T. Closs, Llwyn Peris, Llanberis.
20	College Farm, Aber.

Denbighshire 5.

6	Llysfasi Farm Institute, Ruthin.
7	Henry Hughes, Bachymbyd Bach, Nr. Ruthin.
15	Ellis Tudor, Cernioge Mawr, Glasfryn, Corwen.
16	E. O. Jones, Hafod Dinbych, Glasfryn, Corwen.
17	L. Edwards, Bodtegir, Llanfihangel G.M., Corwen.

Merionethshire 5.

9	Moses Griffith, Egryn, Dyffryn.
8	E. Francis Jones, Caerynghylliad, Trawsfynydd.
10	Pierce Jones, Cynfal, Festiniog.
11	R. H. Davies, Cors y Gedol, Dyffryn.
12	T. Edwards, Hendre Eirian, Dyffryn.

All the farmers showed every desire to carry out instructions, and took a great deal of trouble in carrying through their part of the test. Each was asked to set aside forty ewes at washing time, to wash half of the lot in the way customary on the particular farm, and to shear the remaining half without washing. In one case, owing to a misunderstanding, only twenty ewes were taken for the test. As soon as possible after shearing, the farmer was visited and the individual fleeces of each of the two lots of wool were weighed, then each lot was packed separately and sent to Bradford, where the lots were again weighed. It is satisfactory to note that there was no discrepancy worthy of notice between the weights on the farm and at Bradford. In nearly all cases the weights agreed to an ounce or two.

At Bradford, the procedure in determining the yields of the various lots of wool as received was as follows :—

1. Duplicate representative samples of 2 or 3 lb. each were taken from each lot. These were dried in the ovens and the dry weight of the unscoured wool, including grease and foreign matter, obtained. 16 per cent. was then added to this figure and the difference between the figure

and the weight taken originally expressed as so much percentage loss or gain on the original amount taken. A gain means that the regain of the wool was less than 16 per cent., a loss that it was greater. For example, if 2.5 lb. were taken originally and dried, the dry weight + 16 per cent. might be equal to 2.6 lb. This is expressed as a gain of 4 per cent.

2. 20 lb. of wool exactly was then taken from each lot, and on the basis of the gain or loss previously discovered the 20 lb. was adjusted to a new figure, which is what the raw wool would have weighed had it contained 16 per cent. of moisture instead of the actual figure. In our example, with " 4 per cent. gain ", the 20 lb. becomes 20.8 lb.
3. After complete scouring, the lot was dried in the standard manner in the ovens and the dry weight determined. 16 per cent. was added to this figure.
4. The percentage of yield + 16 per cent. regain given in the table (page 141) expresses the relation between the original weight taken for scouring and then adjusted (that is, 20.8 lb.) and the final figure obtained as described in paragraph 3 above.

Discussion of results.

1. In the table, an attempt has been made to divide the farms into lowland and mountain. The lowland farms are all enclosed farms without mountain grazing. The land varies considerably in height above sea level, and has all been cultivated at one time or another. Except in the case of No. 4, where a permanent flock of Welsh sheep is maintained, the sheep were all Welsh ewes which had been bought nine to twenty-one months previously direct from mountain farms. The centres in the second section of the table are nearly all farms on which a permanent flock of Welsh sheep is maintained, and on all there is a rough hill or mountain grazing, where the flock spends the summer. In some cases the ewes had also been kept on mountain land during the winter, but more often they had been kept on lower ground, either enclosed fields of Ffridd land, for at least part of the winter.

2. It is interesting to note the effect on the wool when mountain sheep are kept on low ground for one or two seasons. The sheep in all cases were of the same general type—ordinary Welsh Mountain ewes—but, comparing those in the first section of the table with those in the second, it will be noticed that the

average weight of the fleeces is about ½ lb. greater as a result of the sheep having been kept for some time under lowland conditions. If allowance were made for the fact that in four or five of the mountain farms the sheep selected for the test were yearlings, the difference would be still greater. The loss in weight on washing is also slightly more in the lowland than in the mountain flocks, but the main difference is the distinctly lower yield from both the washed and the unwashed wool. *Unwashed* lowland wool gave an average yield of 67½ per cent. as compared with nearly 72 per cent. in the case of mountain wool. Similarly, the *washed* lowland wool gave rather less than 75 per cent. yield, whereas the washed wool from mountain farms gave 79 per cent. The difference is, presumably, mainly due to the greater amount of " grease " in the wool of sheep kept under good lowland conditions. On the average, there was little difference in the periods between washing and shearing in the two lots, so that this could not affect the results.

3. It is interesting to note that the unwashed wool in every case contained more moisture than the washed wool, suggesting that the " grease " of the wool absorbs and retains more moisture than the wool substance itself does. The fact that the difference is greater in the case of the lowland sheep than the mountain sheep confirms the view that the difference in the yields of the two classes of wool is mainly due to different amounts of grease, and not to differences in the amounts of sand and other extraneous matter.

4. The approximate ranges of yields and of the relative values from these yields as shown in the last column of the table on p. 141 were as follows :—

		Washed.	*Unwashed.*
Lowland Flocks.			
Widest	...	119.5	100
Narrowest	..	103	100
Average	..	111	100
Mountain Flocks.			
Widest	..	119	100
Narrowest	...	103	100
Average	...	111	100
All Flocks.			
Widest	...	119	100
Narrowest	...	103	100
Average	..	111	100

Thus, on the average, the difference between 10d. and 11d. a lb. would approximately represent the difference in value between the unwashed and the washed wool, as measured by the difference in yield. There is, however, great variation among the individual lots, both lowland and mountain. For instance, at centres 8, 10, 11, and 18, if the yield from the unwashed wool is

taken as 100, the yield from the washed wool was 108 or 104. At centres 6, 14, 16, and 17, the corresponding figure was more than 115.

5. Although care was taken in selecting level pairs of lots for the experiment, it is obvious that in some cases the sheep had not been particularly uniform. At two centres the twenty washed fleeces weighed more than the twenty unwashed fleeces, although the yields from the washed wool were in each case higher than from the unwashed. It is, therefore, impossible to place too much emphasis on the average percentage loss of weight, but it is interesting to note that, taking the average of all sheep in the trial, the difference in weight gives a proportion very similar to that calculated from the yields obtained at Bradford. The total weight of the washed wool was 915 lb., that of the unwashed wool 1033 lb., very near the proportion of 10 : 11.

6. It was expected that the results would show a close connection between the loss in weight on washing and the shortness of the period between washing and shearing, but an examination of the figures fails to reveal the expected correlation. The correlation between the number of days' interval and the difference between the yields of the washed and unwashed lots is $+ 0.10$, which is, of course, not significant.

7. Perhaps the most striking fact brought out by the experiment is the great difference in the yields of scoured wool from the clips of the different centres. The differences are naturally greater in the unwashed wool than in the washed wool, but, even if the washed wool is considered, it will be noticed that the yield varies from about 70 per cent. in one or two lowland lots to more than 80 per cent. in several of the mountain farms. It is difficult to compare one mountain farm with another, as so many considerations besides altitude and nature of grazing have to be taken into account, but, roughly speaking, there is no doubt that the yield is greatest from the highest and most exposed mountain farms. This may be due partly to the effect of the high rainfall on the wool while still on the sheep's back, and partly to a lower production of grease as a result of the inferior food and the hard conditions generally. Even in the case of the lowland flocks, it is perhaps not without significance that the highest yield in this section is from farm No. 5, which, although consisting of well-treated young grassland, is about the highest and most exposed of its section.

It is not unfair to say that, other things being equal, the value of a particular lot of wool to the manufacturer may be measured by its yield as tested by the Bradford Conditioning

House. In the case of wool from overseas, for instance, Australian and South African Merino, the manufacturer may buy wool on the basis of the Bradford test, and, in any case, he estimates its yield before bidding for it. The results brought out by this experiment would suggest that some mountain farms, at any rate, would benefit considerably if Welsh wool were valued in the same way. With a clip of 2,000 lb. washed wool, and a yield of 80 per cent., the net weight of wool received by the manufacturer is 1,600 lb. A clip similar in every respect, but only yielding 70 per cent., would only give the manufacturer 1,400 lb.—a difference between the two lots of 200 lb. of *scoured wool*, which, in times of normal prices, would represent a fairly substantial sum.

General conclusions.

Returning to the point which the experiment was designed to test, the results may be summed up as follows :—

Taking the average of the nineteen lots of wool, the difference between 10d. and 11d. a lb. would about represent the difference in price necessary to secure the same total return from washed and unwashed wool. It is obvious, however, that such an average result may be very misleading if applied to any individual farm. It seems probable that on many mountain farms the loss in weight on washing will not exceed 5 per cent. or 6 per cent. On these farms a very small increase in the price for washed over unwashed wool will make the operation well worth while. It is probable that such farms will be found in exposed situations in districts of high rainfall and poor general conditions. On the other hand, it seems probable that on a proportion of farms the loss in weight as a result of washing will be as much as 20 per cent. Such farms are likely to be largely of lowland type, less exposed, or to have a comparatively low rainfall. It is obvious that on such farms the difference between the price for washed and that for unwashed wool must be much greater than in the former class. If, on a particular farm, wool loses 20 per cent. in weight on washing, the difference in price between washed and unwashed wool should be greater than the difference between 6.4d. and 8d. per lb. to make the operation worth while. Taking a higher level of prices, if unwashed wool is worth 1/-, then, with a 20 per cent. loss, washed wool ought to make at least 1/3 to give the same cash return from the same flock of sheep.

We wish to record our appreciation of the great help given by the County Agricultural Organisers and the farmers who co-operated, and of the care that they took in trying to make the test as accurate as possible.

We are also greatly indebted to Professor Ashby, who originally suggested the scheme, and to Mr. Fraser Roberts, of the Wool Industries Research Association, Torridon, who has been most helpful in many ways throughout the test.

No. and Type of Farm. Lowland Mountain.	*Age of Ewes. Years.*	*No. of days Washing to Shearing.*	*Weight of 20 Unwashed Fleeces at Farm. lb.*	*Weight of 20 Washed Fleeces at Farm. lb.*	*% Weight Washed to Unwashed.*	*% Moisture in Wool.*		*% Yield of Unwashed. Allowing 16% for Regain.*	*% Yield of Washed.*	*Ratio of Yields Washed to Unwashed. Yield of Unwashed=100.*
						Unwashed.	*Washed.*			
1 L	4, 5	10	27*	20*	74.0	16.15	13.58	67.6	75.5	111.7
2 L	4, 5	8	65	52	80.0	16.88	14.65	65.0	71.2	109.5
3 L	4, 5	5	73½	68	92.0	17.31	11.45	68.4	70.4	103.0
4 L	1, 2	4	74½	62	83.0	17.56	12.95	64.3	76.8	119.5
5 L	3, 5	7	56	54	96.4	16.29	13.73	71.8	79.6	110.9
7 L	5	6	52	50	96.1	16.70	14.55	68.0	75.5	111.0
Average of Lowland farms			3.17 lb. †	2.78 lb. †	87.9	16.81	13.48	67.5	74.8	111.
6 M	4	12	52	38	73.1	17.23	14.12	65.9	75.8	115.0
8 M	2, 3	5	49	40	81.6	16.82	16.74	74.8	77.9	104.1
9 M	2	4	47½	43	91.0	14.94	14.61	72.5	79.3	109.4
10 M	1, 2	8	53	51	96.2	16.15	15.02	73.7	76.1	103.2
11 M	3, 4	4	56½	58	102.7	16.27	14.26	80.8	84.2	104.2
12 M	3, 4	7	55½	50½	90.9	14.03	13.11	72.5	78.0	107.6
14 M	1, 2, 3	15	59	54	91.5	14.89	14.55	68.7	79.5	115.7
15 M	1	12	47½	37	77.8	16.76	13.32	67.4	76.4	113.4
16 M	1, 2	11	46½	35½	78.5	17.31	13.73	67.8	78.4	115.6
17 M	2, 3	5	44	47	106.8	16.84	14.30	67.8	80.7	119.0
18 M	3, 5	11	52	45	86.5	15.96	14.73	80.9	83.4	103.1
19 M	1	1	49	48	97.9	15.84	15.47	71.5	80.6	112.7
20 M	1	3	74	62	83.7	15.82	13.97	68.3	78.1	114.3
Average of Mountain farms			2.64 lb. †	2.34 lb. †	88.9	16.07	14.46	71.7	79.1	111
TOTAL FOR 19 CENTRES			1,033¼	915						
AVERAGE FOR 19 CENTRES.			2.79 lb.	2.48 lb.	88.5	16.30	14.15	70.4	77.75	111

*10 Fleeces only. †Average weight of one fleece.

OBSERVATIONS ON THE EFFECT OF VARIOUS MANURES ON (*A*) YIELD OF HAY AND (*B*) BOTANICAL COMPOSITION OF THE HERBAGE OF MEADOW-LAND.

WITH A NOTE ON NATIONALITY STRAINS OF VARIOUS GRASSES.

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A trial was commenced in 1924 at the College Farm of the University College of North Wales, Bangor, in order to test various systems of manuring meadow-land (the term meadow is used in its usual technical meaning, *i.e.*, permanent pasture land mown for hay every year or nearly every year). The experiment was carried out in accordance with a scheme drawn out at the Welsh Agricultural Education Conference in 1921, the only modification being the introduction of an additional control plot and of a plot manured with a dressing of complete artificials annually with ground limestone every third year. Table I shows the manures applied to the various plots, which occupy the same relative order in this table as in the field.

TABLE I.

Plot.	*Scheme of manuring.*
1	Farmyard manure annually.
2	Farmyard manure and Basic Slag in alternate years.
3	No manure.
4	Slag alone annually.
5	Complete artificials annually with ground limestone every third year.
6	Complete artificials annually.
7	Complete artificials minus potash annually.
8	No manure.
9	Complete artificials minus phosphate annually.
10	Complete artificials minus nitrogen annually.

The field selected for this trial had been laid down to grass in 1923 under oats, and after mowing for hay in 1924, the first manurial dressings were applied in the autum of that year. The soil is a medium loam overlying a stiff clay subsoil, which renders drainage very difficult. Surface drainage was encouraged

by laying down the field in lands of ten yards width, with well defined open furrows. The field is at sea level, and is almost flat. The plots are each half an acre in area, each plot consisting of one land, *i.e.*, of the area lying between two furrows. Table II shows the seeding for the establishment of these swards in 1928.

TABLE II.

	Lb. per acre.
Italian ryegrass (French)	4
Perennial ryegrass (Registered Ayrshire)	12
Cocksfoot (English)	5
Timothy (Canadian)	5
Rough stalked meadow grass	½
Crested dogstail	½
Broad red clover (English)	2½
Late flowering red clover (English)	2½
Wild white clover (Kent)	½

The plots were examined botanically in January and February of 1930, the percentage by weight of the chief ingredients being determined according to the interim recommendations of the Pasture Analysis Sub-Committee of the Agricultural Education Association.

Treatment of Plots.

The phosphatic manure used was basic slag of about 14 per cent. phosphoric acid, and applied at the rate of approximately 6 cwt. per acre after the plots had been well grazed in the autumn. The potash and nitrogen manures were applied in March or April, the former as kainit at the rate of 4 cwt. per acre, and the latter as sulphate of ammonia at 1 cwt. per acre. The ground limestone was applied at the rate of 10 cwt. per acre in the winter of 1924-5, and 18 cwt. in the winter of 1927-8. The farmyard manure was applied at the rate of about 8 tons per acre, being put on between November and March; the manure was unrotted, being generally carted direct from the yards and boxes.

The plots have been mown every year, and the aftermath grazed by dairy cows. The field has been grazed by sheep each winter, and put up for hay at the end of April.

In 1924 and 1930 the produce of the plots was weighed as hay, a portion of the plots consisting of about one-fifth of an acre being cut and harvested separately. In the other years the crop was weighed in the green state, and then put into the silo.

This method has the advantage that the weighing can be completed the day after mowing, whereas, when the crop is weighed as hay the crop on each plot has to be kept strictly separate through a period of harvesting which is sometimes long and difficult. Weighing in the green state is open to the disadvantage that the proportion of dry matter may vary in the different plots, and also that, even in the short interval between mowing and carting, a light crop would lose a greater proportion of moisture during hot weather than a heavy crop.

Yield of hay.

Table III shows the yields from the plots expressed as hay for each of the years 1925, 1926, 1927, 1929, and 1930. In the last column but one the average yield for the five years is given; in the last column the average yields are expressed on a scale obtained by putting the lowest no manure yield at 100.

TABLE III.
Yield of hay.

	1925		*1926*		*1927*		*1929*		*1930*		*Average 1925-30.*		
Plot.	*Cwt.*	*qr.*	*Cwt.*	*qr.*	*Cwt.*	*qr.*	*Cwt.*	*qr.*	*Cwt.*	*qr.*	*Cwt.*	*qr.*	
1	35	0	36	0	28	2	31	1	46	0	35	1	141
2†	33	1	18	2	28	1	24	3	38	1	28	2	114
3	26	1	20	0	21	1	22	0	35	1	25	0	100
4	22	0	18	2	24	3	16	0	33	1	23	0	92
5	34	2	32	0	26	3	23	1	44	1	32	1	129
6	35	0	*21	2	27	0	22	3	43	2	30	0	120
7	32	0	26	0	19	0	19	2	38	3	27	0	108
8	24	0	27	2	20	2	17	1	37	2	25	1	101
9	36	1	27	0	23	2	26	2	44	3	31	2	126
10	36	0	26	0	25	0	20	0	45	0	30	2	122

† Farmyard manure was applied for the 1925, 1927, and 1929 crops, and basic slag was applied for the 1926, 1928, and 1930 crops.

* The Kainit was applied to plot 7 instead of to plot 6 in the spring of 1926.

(1) *Farmyard manure.* The plot dressed annually with farmyard manure has not only given the highest average yield, but has not been significantly exceeded by the yield of any other plot in any one year, despite the climatic variations covered by the period of the trial. The results leave no doubt as to the efficacy of annual dressings of farmyard manure in increasing the yield of meadow hay. The average annual increase over the no manure plots is 10 cwt. or 40 per cent. Reference to the botanical composition of the plot, given later, shows that the

annual application of farmyard manure was not accompanied by any deterioration as measured by the botanical composition of the herbage.

(2) *Basic Slag.* The plot dressed with basic slag alone every year has proved a surprising result, the average yield from this plot being lower than that of both of the control plots; if the results are considered separately for each year, it will be observed that the yield of hay from the slag plot was lower than that of either of the control plots in four out of the five years. Further evidence of the depressing effect of slag on the yield is afforded by the results from plots 2 and 9, *i.e.*, from the plots receiving farmyard manure and slag alternately and from the plot dressed with complete artificials minus phosphate each year. In plot 2 the average yield for the period is a little less than half way between the no manure plots and the farmyard manure plot. A consideration of the yield given each year shows that, with the exception of the year 1929, when the season was very dry, the yield in plot 2 has approximately equalled that in plot 1 in the years when farmyard manure was applied, and that it fell considerably short of that on plot 1 in the year when slag was applied.

	Years when farmyard manure was applied to plot 2.	*Years when slag was applied to plot 2.*
Average yield of plot 1	31 cwt. 2 qr.	41 cwt. 0 qr.
Average yield of plot 2	28 cwt. 3 qr.	28 cwt. 1 qr.
	3 cwt. 3 qr.	12 cwt. 3 qr.

Thus, even when 1929 is included, the difference between the yield of plots 1 and 2 is considerably smaller in the years when plot 2 was dressed with farmyard manure. The effect of omitting slag from a dressing of complete artificials is seen in a comparison of plots 6 and 9 in Table II. The plot receiving kainit and sulphate of ammonia has given a slightly higher yield in four out of the five years than the plot receiving the same dressing with an addition of slag. The difference is small but it at least shows that no beneficial effect on yield resulted from the addition of slag.

The effect of basic slag on the botanical composition of the herbage is discussed later; annual dressings of slag tended in this trial to increase the proportion of weeds, and the proportion of wild white clover was no higher than in the control plots.

(3) *Potash.* The trial brings to light the beneficial effect of potash on the yield and on the quality of the herbage. This result was not entirely in accord with expectations since it is generally assumed that, on medium and heavy soils, potash is rarely required for grass and hay. In this trial, plot 6 gave a higher yield than plot 7 in every year except 1926, when the potash was applied to the latter in error. Omitting 1926, the average relative yields of plots 3, 6 and 7 become :—

Plot 3.	No manure	100
Plot 6.	Complete artificials	128
Plot 7.	Complete artificials but without potash ...	109

The omission of nitrogen from the dressing of artificials had had little effect on the yield. The plots receiving sulphate of ammonia were darker in appearance after the application of the manure until within a short time of mowing. In November, 1927, it was observed that the four plots in the trial which had received sulphate of ammonia in the spring were much more brown in appearance than all the other plots, this difference being easily observable from a distance.

(4) *Lime.* A comparison of plots 5 and 6 shows that an application of ground limestone in the winter of 1924-25 and another in the winter of 1927-28 has had no effect on the yield of hay. Plots 5 and 6 were dressed with complete artificials each year, and plot 5 was given, in addition, a dressing of limestone every third year. The yields in 1926 are omitted, the year when plot 6 was (in error) not dressed with kainit, the yields of hay in the other four years were almost identical in these two plots each year.

Botanical composition of the herbage.

The herbage population of the various plots, determined in winter, and after an interval of close upon seven years from seeding, is given in Table IV.

In the case of each plot the figures in column 9, unsown species, represents the sum of the figures given in columns 7 and 8, moss and miscellaneous species respectively.

It is useful to single out the features that the figures would seem to indicate in the case of some of the plots.

Plot 1. Receiving dressings of farmyard manure annually. From a plant population viewpoint, the notable features here are the high percentage of perennial ryegrass—the highest recorded for the series, the satisfactory figure for wild white clover, and the low incidence of miscellaneous unsown species, the figure being the lowest recorded for the whole series of plots.

Apart from considerations of bulk, where premier position is also held by this plot on the score of yield, as seen elsewhere the quality and the texture of this plot are excellent.

TABLE IV.

Plot.	Percentage occurrence of species.								
	Perennial ryegrass.	*Cocksfoot.*	*Timothy.*	*Rough stalked meadow grass.*	*Crested dogstail.*	*Wild white clover.*	*Moss.*	*Miscellaneous.*	*Unsown species.*
1. Farmyard manure annually ...	38.3	7.3	4.8	12.5	3.3	25 2	...	8.5	8.5
2. Farmyard manure and basic slag in alternate years	33.5	6.1	5.3	11.5	5.3	25.1	2.0	11.1	13.1
3. No manure	30.8	4.4	1.1	11.7	10.5	15.7	6.8	15.9	22.7
4. Slag alone annually ...	23.9	2.4	5.3	16.9	7.9	19.6	6.7	17.4	24.1
5. Complete artificials annually with ground limestone every third year	29.1	5.2	3.6	16.9	11.3	25.1	1.7	7.0	8.7
6. Complete artificials annually ...	28.2	3.7	4.0	13.7	9.1	30.0	1.8	9.4	11.2
7. Complete artificials minus potash annually	30.0	6.5	4.7	16.3	8.4	15.6	7.9	10.7	18.6
8. No manure	28.8	6.0	1.6	9.8	11.8	12.9	6.0	20.2	26.2
9. Complete artificials minus phosphate annually	23.8	9.7	7.3	9.1	9.2	28.0	4.0	8.9	12.9
10. Complete artificials minus nitrogen annually	25.6	5.3	5.5	15.0	5.4	25.6	4.3	13.3	17.6

Plot 2. Receiving farmyard manure and slag in alternate years. The botanical composition of this plot approaches very closely to that of the preceding plot; the percentage of perennial ryegrass is slightly lower, and there is a slight increase in the percentage of weed flora.

Plots 3 and 8. Control plots receiving no manures throughout. Unsown species figure somewhat more prominently here than they do in the majority of the other plots. Crested dogstail also figures more prominently than it does elsewhere as one would normally expect. The impoverished condition of the soil is however best indicated by the low figures for wild white clover on this plot—less than half the representation on most of the other plots. The high figures for perennial ryegrass on both control plots would seem to indicate a fairly high level of fertility even here. This can probably be explained by the water retaining capacity of the soil, by the fact that this grass withstands treading by stock surprisingly well, and by the fact that a good deal of manurial residues are dropped on these controls in the eight or nine months of the year that stock roam indiscriminately over the whole of the field.

Plot 4. Receiving slag alone each year. The most surprising result of the whole series of plots is the poor performance of this plot throughout the sequence of seasons. This fact is borne out by yields, by the impoverished appearance of the sward at all seasons, and by the result of botanical analysis of the herbage. Outside the control plots, nowhere has the white clover figure proved so low. Similarly the ryegrass figure stands at its lowest for the series. This parallel depression of the two species, wild white clover and perennial ryegrass, has been noted by us previously, and is again borne out in the present series. The similarity between the herbage on this plot and on the no manure plots is indicated by the high incidence of crested dogstail on both. Indeed it would seem that judging by the figures representing unsown species (24 per cent. on the slag plot, 28 per cent. and 26 per cent. respectively on the two controls) the slag plot generally is on a par with the controls, varying from them as they vary from each other.

Plot 5. The use of complete artificials together with a dressing of ground limestone every third year has resulted in a sward with a percentage of sown species closely similar to that on the plot receiving farmyard manure annually. The relative proportion of the respective elements is however slightly different. Perennial ryegrass has decreased by 9 per cent., with a corresponding increase in the smaller sized species, rough

stalked meadow grass and crested dogstail. The wild white clover representation is identical with that on plot 1. The lack of response to ground limestone may be attributed to the fact that the soil, though devoid of $CaCo_3$, contains lime combined in available form with clay and organic matter. The actual content of lime in this state is 0.4 per cent. and the pH figure is 6.2.

Plot 6. Complete artificials applied annually. The population of this sward is surprisingly similar to that of the preceding plot. The figures here on the score of botanical analysis bear out and support the conclusion come to separately on the score of yield, viz., that the extra cost of supplying ground limestone to ground already in receipt of dressing of complete artificials is not justified.

Plot 7. With the exception of potash, receiving complete artificials annually. The outstanding feature of this plot is its poverty in wild white clover. The proportion of this species recorded is the lowest of all the plots receiving manurial dressings. Apart from this, the quality of the herbage is good and relatively free from undesirable weeds; the ground released by lack of wild white clover development apparently being filled by the pioneer bottom grass, rough stalked meadow grass, introduced in the seeds mixture. The loss of bulk on this plot recorded in the yield section would appear to be accounted for by the lower development of wild white clover on this plot.

Plot 9. Omitting phosphate from the complete artificials annually. The omission of phosphate has in no way proved disastrous. While perennial ryegrass has decreased, cocksfoot and timothy have filled the gap; wild white clover has not suffered to any extent, for excepting the complete artificials plot nowhere does the figure for this element stand as high as it does here. Similarly the plot is remarkably free from weeds, and robust and healthy in growth of good texture.

Plot 10. Receiving complete artificials minus nitrogen each year. Compared with the plot receiving a dressing of complete artificials the chief effect of omitting nitrogen appears to be that the weed population has increased with a resultant decrease in wild white clover. Perennial ryegrass reflects the fact also, and to a smaller extent crested dogstail also.

Conclusions.

(4) *On the basis of yield.*

1. A number of systems of manuring meadow land have been under trial. These systems are not necessarily suitable for adoption in general farm practice, but they

have been tried to obtain information on certain points of fundamental importance.

2. An annual dressing of farmyard manure has resulted in a greater yield of hay than that from any of the combinations of artificial manures tried, and has proved superior to dressings of this manure and slag applied in alternate years.
3. A dressing of basic slag applied each year resulted in depressing the yield. When applied annually with potash and nitrogen no increase resulted from the use of slag.
4. An appreciable return resulted from the use of potash.
5. No return was shown for the application of ground limestone every third year to land that received besides dressings of complete artificials.

(*B*) *On the basis of botanical composition of the sward.*

The botanical composition of the swards bears out very closely the conclusions drawn above on the score of yield. The outstanding features are :—

1. The high incidence of perennial ryegrass and wild white clover, and the low incidence of miscellaneous weeds on plot 1 receiving farmyard manure each year.
2. The closeness with which plots 2, 5, and 6, receiving respectively farmyard manure and slag in alternate years, complete artificials each year with ground limestone in addition every third year, and complete artificials, all approach to the high quality of herbage found on plot 1. The extra cost of supplying limestone to plot 5 is not justified on the score of botanical composition more than on the score of yield.
3. The poor establishment of wild white clover on plot 7, where potash is omitted as an ingredient in an otherwise complete dressing of artificials, and the consequent loss of yield.
4. The reflection of the omission of nitrogen in plot 8 to be noticed in increased spread of weeds, and the depression of both wild white clover and perennial ryegrass.
5. The consistently poor performance of plot 4 receiving slag each year. The sward appears impoverished at all seasons, the representation of clover and perennial ryegrass is surprisingly low, and the weed elements thrive as nowhere else on the plots. The omission of phosphate on plot 9 supports this finding, for its absence has in no way proved disastrous to the sward.

It would seem that these results offer a challenge to the thought, until recently accepted, that given a satisfactory initial take of permanent clover species, by judicious application of phosphates this take could be long maintained, and that the clover would in turn support a robust gramineous element by the enrichment of the soil in nitrogen.

TABLE V.

	Seed per acre (lb.).				
	1	*2*	*3*	*4*	*5*
Italian ryegrass (French) ..	4	4	4	4	4
Perennial ryegrass (Registered Ayrshire) ..	7	7	7	7	7
Meadow fescue	5 (American)	5 (Danish)	5 (Danish)	5 (Danish)	5 (Danish)
Cocksfoot	5 (Danish)	5 (English)	5 (New Zealand)	5 (Stapledon B.C. 20 1)	5 (Stapledon B.C. 2/1)
Timothy	5 (American)	5 (Scottish)	5 (Scottish)	5 (Scottish)	5 (Scottish)
Rough stalked meadow grass	½	½	½	½	½
Crested dogstail	½	½	½	½	½
English broad red clover ...	2½	2½	2½	2½	2½
English late flowering red clover	2½	2½	2½	2½	2½
Wild white clover (Kent) ...	¼	¼	¼	¼	¼

It is generally maintained, too, that land of this type is not in need of potash manure. The results given on plot 7 would

suggest that, at least for the maintenance of good grass to be made into hay, we have need to reconsider, and maybe to amend our belief as to the efficacy of this element under these conditions.

Test of nationality strain of various grasses.

In addition to the land seeded in 1928 for the manurial trials already discussed, five similar plots were laid down with a view to testing the effect of the country of origin of the seeds of meadow fescue, cocksfoot, and timothy on the permanency of the sward. The seeding of these plots is given in Table V (p. 151), the weight of seed being the same for each species. Table VI gives the seeding of a simple mixture plot included on Professor R. G. Stapledon's recommendation, on the basis of its proved usefulness for Mid-Wales.

TABLE VI.

	lb. per acre.	
Italian ryegress ...	4	French.
Perennial ryegrass ...	20	Registered Ayrshire.
Late flowering red clover	4	English.
Wild white clover ...	1½	Kent.

The botanical composition of the swards on these six plots in their seventh year from establishment is shown in Table VII, and some interesting conclusions can be drawn from a consideration of the figures.

The representation of the strains of different nationalities in the three species concerned alone present some interesting features.

Cocksfoot. The striking fact here is the successful manner in which the two strains, Bc. 20/1 and Bc. 2/1, isolated at the Welsh Plant Breeding Station at Aberystwyth, have established and maintained themselves. The Danish strain proves poorest; it has all but disappeared. This fact bears out the former observations drawn from earlier work by one of the present writers. The New Zealand and English strains of this grass, each put on the market as mowing strains, are identical in representation. They are both mass selections, and while they prove superior to the Danish strain, they are far below the pedigree strains evolved at Aberystwyth.

These figures bear out the infinite variation which exists within different strains of the same species, and the importance of

TABLE VII.

Percentage composition by weight.

Species.	*Plot 1.*			*Plot 2.*			*Plot 3.*			*Plot 4.*			*Plot 5.*			*Simple Mixture Plot.*
	Danish.	*American.*	*American.*	*English.*	*Canadian.*	*Danish.*	*New Zealand.*	*Scotland.*	*Danish.*	*Stapledon Bc. 20/1.*	*Scotland.*	*Danish.*	*Stapledon Bc. 2/1.*	*Scotland.*	*Danish.*	
SOWN AND VARIABLE.																
Cocksfoot	1.0			10.0			10.1			24.2			28.3			...
Timothy		6.1			1.9			6.4			6.5			6.3		0.4
Meadow fescue			...			...			...			...			...	...
SOWN AND COMMON TO ALL.																
Perennial ryegrass ...		24.2			24.4			17.2			14.4			15.6		37.8
Rough stalked meadow grass		20.2			23.0			14.8			11.6			14.0		14.7
Crested dogstail		8.2			6.1			9.6			3.7			1.3		2.8
Wild white clover ...		18.5			12.9			28.5			31.5			24.2		27.2
Red clover		...			...			...			...			...		...
MISCELLANEOUS UNSOWN.																
Moss		7.0			2.3			3.1			...			...		4.8
Other species		14.8	21.8		19.4	21.7		10.2	13.3		8.0	8.0		10.2	10.2	12.2 17.0

the adoption of pure line selections and of pedigree strains of a herbage grass such as cocksfoot, the importance of which as a pasture element in a grass area like ours, largely devoted to sheep, is so apparent.

Timothy. The Scottish timothy strains tested proved very similar, being practically identical in take with the American strain tested, and all alike being superior to the Canadian strain tested. This grass fares badly under conditions of close grazing by sheep; under meadow conditions it thrives, but the actual bulk in a mixed herbage is always far below what the eye suggests for it in a standing hay crop.

Meadow fescue. No trace of any of the strains of this grass sown survives after seven years. This was to be expected under our conditions, for the sensitiveness of this species under competition is well established.

Several other observations emerge when we examine the effect of these various strains on the other elements in the sward. The two plots (4 and 5) with the highest proportion of sown species, alike high in cocksfoot, are marked by the high incidence of wild white clover on them; and whilst there is a tendency for the combined growth of cocksfoot and timothy to suppress perennial ryegrass, when the former species falls off, an increase not only in perennial ryegrass is produced, but also in the bottom grasses, such as rough stalked meadow grass and crested dogstail. This suggests that these latter species, notably the meadow grass, ordinarily non aggressive, are yet able to withstand considerable competition from aggressor species.

The behaviour of the miscellaneous unsown species is interesting also. Composed of varying amounts of *Bellis* spp., *Ranunculus*, Fog, Mouse-eared Chickweed, *Agrostis* spp. and Sweet Vernal, they increase as the cocksfoot and timothy decrease, suggesting that perennial ryegrass and bottom grasses are not so successful in depressing them.

In nearly all the plots, wild white clover has figured prominently. The relative proportions of rough stalked meadow grass and wild white clover confirm once more the earlier findings of one of the writers, that these two species are in direct competition for the colonization of the same layer of herbage space.

Consideration of the figures in the last column of Table VII, the simple mixture plot, shows clearly that excellent cover and keep may be provided from the use of a seeds mixture with but few elements to it. Four-fifths of the herbage consists of the three species, wild white clover, perennial ryegrass, and meadow grass after an interval of seven years, and once more the way

in which the two former species thrive collaterally is strongly marked here. There is nothing here to indicate the wild white clover status of this plot in the first years after establishment; although the seed rate here was thrice what it was elsewhere in this series, its establishment at this stage in the history of the ley is only on a par with that showing on the other plots.

EXPERIMENTS ON THE DEPTH OF SOWING AND THE TIME OF SOWING SAINFOIN.

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Sainfoin, on account of its feeding value as forage and hay, would be a much more favoured crop were it not for the reputation it has of being difficult to establish. Its special soil requirements are well known, and it is liable to sickness, but even on soils and farms where it is usually grown, a stand cannot be guaranteed. It is surmised that this may often be due to sowing at the wrong depth, or with insufficient cover, or at an unfavourable time. Considering the various ways and times of sowing, and the different implements of varying efficiency employed, these factors should be examined.

I. Depth of sowing.

Sainfoin seed when milled is about three times the size of red clover seed. It has been recommended that it should be sown a little deeper than red clover (1). Percival (8) mentions about one inch deep. Williams (6), who experimented on the depths of sowing red and white clovers, perennial ryegrass, cocksfoot, meadow foxtail, and rough-stalked meadow grass, found that with red clover the best depths in light loam appeared to be ½ in. to ¾ in., there being very poor establishment when the seeds were not covered, many seedlings were unable to reach the surface if buried deeper than one inch, and when the soil was dry, germination at the surface was slower.

As far as the writer is aware, no experiments are on record concerning the most suitable depth for sowing sainfoin, or, in other words, the amount of soil cover which is necessary to give the best germination and establishment.

Experiments to determine this were carried out at the Cardiff College experimental ground, at twelve depths in 1927, at eight depths in 1928, and at six depths in 1929. The soil can be described as light drift, loamy, well supplied with lime, phosphates and potash.

The 1927 experiment.

In 1927, milled common sainfoin seed was used, the laboratory germination being 81 per cent.

The bed was made up of carefully sifted soil placed in a frame divided into twelve sections, one section for each depth of sowing. After levelling the surface, the required depth was obtained by a dibble. One seed was placed in each hole so made. Two hundred seeds were sown in each division at one inch intervals, in rows two inches apart, on the 11th of May. The beds were watered when necessary and protected from birds by a ½ in. wire netting.

Counts of the plants which had appeared above ground were made on May 21, May 28 and June 4, i.e., on the tenth, seventeenth and twenty-fourth days.

On the 10th of October, the plants were lifted and counted, giving the total number of plants which were established at the end of the season. The depths and the plant counts at the different dates are given in Table I. On such a bed, with the conditions prevailing, for depths less than ⅜ in., the maximum germination had taken place in seventeen days. For greater depths germination was slower, but those plants stood until the end of the season. The quickest or highest germination was obtained at ⅛ in., but ¼ in. gave quite as good final " plant ".

TABLE I.

To show the number of Plants at each count per 200 seeds sown.

Date of Count.	*Surface.*	⅛ *in.*	¼ *in.*	⅜ *in.*	½ *in.*	⅝ *in.*	¾ *in.*	1 *in.*	1¼ *in.*	1½ *in.*	1¾ *in.*	2 *in.*
May 21	5	76	58	41	38	26	34	5	3	6	1	2
May 28	20	87	79	57	64	52	51	21	24	35	17	23
June 4	22	85	77	56	69	53	57	24	31	38	18	29
Oct. 10	18	73	75	52	61	52	56	23	32	34	18	30

The 1928 experiment.

Four lots of seed were used, viz. :—

Lot 1. Giant French milled;
Lot 3. Giant English in husk;
Lot 5. Common Moravian in husk;
Lot 9. Common Cotswold milled.

The plots were situated in a garden bed and worked into fine tilth and levelled. Drills to the required depth were made by

drawing over the surface a board with an attached peg projecting to the required depth.

The drills were 5½ ft. in length and 182 seeds were sown in each drill, at ½ in. intervals and then covered with soil and pressed level with the surface of the bed.

Drills of lots 1 and 8 were repeated five times, and 5 and 9 were repeated three times, so that one plot of one drill per depth of each lot of seed were sown thus :—

Lots 1, 8, 5, and 9, Plot (*a*) on May 22.
Lots 1, 8, 5, and 9, Plot (*b*) on May 23.
Lots 1, 8, 5, and 9, Plot (*c*) on May 24.
Lots 1 and 8, Plots (*d*) and(*e*) on May 25.

Concurrently, two lots of 200 seeds of each lot were sown in sand in the greenhouse on May 21. The results of the greenhouse germination at ten days and twenty-eight days are given in Table II.

TABLE II.

Giant Sainfoin.			*Common Sainfoin.*		
Lot.	*10 days.*	*28 days.*	*Lot.*	*10 days.*	*28 days.*
1	71%	91%	5	37.25%	76.25%
8	43.75%	76.75%	9	50%	78.5%

Counts of " germination " on the bed plots were made on June 4 (twelve days) and June 18 (twenty-six days), and the plots were lifted on the 1st, 2nd and 3rd of November, 1928, for the final count of the establishment.

Considering Table III and detailed graphs of the " germination " on June 6, Lots 1, 8, and 9 gave the highest count for the depth of 1¼ in., with a close count at 1½ in., whilst Lot 5 gave a higher average for 1½ in., showing that in this year, for the quickest germination, about 1¼ in. to 1½ in. was the most suitable depth.

Considering the counts on June 18, the graphs show a change of form, a high peak still obtained at 1¼ in. in all lots, but in Lot 8 a higher count was given by the depth of ½ in., and in Lot 5 by the depth of ¾ in., also in Lot 1 a high peak is given at ¾ in. Common to Lots 1, 8, and 5 is a low germination for all plots at the depth of 1 in. Lot 9 still retains a higher count at 1¼ in., but not so pronounced as on June 6.

When we come to the establishment count at the beginning of November, Lots 1, 5, and 9 show the maximum number of plants at the depth of $\frac{3}{4}$ in., Lot 3 showing the biggest number for the depth of $\frac{1}{2}$ in., all lots showing a high establishment at $1\frac{1}{4}$ in., and except Lot 9 a rather lower number for the 1 in. depth.

TABLE III.

Particulars of the depth and average of counts at the different dates for 132 seeds sown.

Depth	*Lot 1. Giant French milled.* Average count, 4.6.28	Average count, 18.6.28	Average count, 1-3.11.28	*Lot 3. Giant English in the husk.* Average count, 4.6.28	Average count, 18.6.28	Average count, 1-3.11.28
Surface.	0.0	2.4	2.6	0.0	6.2	19.4
¼ in.	3.2	88.4	83.2	0.4	55.6	70.6
⅜ in.	17.6	88.6	76.0	2.0	72.6	82.4
½ in.	44.0	98.4	93.6	6.2	65.0	74.6
1 in.	68.2	95.2	85.8	17.8	62.8	70.0
1¼ in.	84.2	99.8	95.4	24.8	71.0	76.4
1½ in.	82.4	88.6	84.2	23.8	64.0	74.6
2 in.	80.4	85.0	79.8	22.8	49.8	57.4

Depth	*Lot 5. Common Moravian in the husk.* Average count, 4.6.28	Average count, 18.6.28	Average count, 1-3.11.28	*Lot 9. Common Cotswold milled.* Average count, 4.6.28	Average count, 18.6.28	Average count, 1-3.11.28
Surface.	0.0	21.3	26.6	0.0	4.3	5.3
¼ in.	1.0	87.0	83.6	0.0	58.0	61.0
⅜ in.	7.0	86.6	84.6	6.0	69.3	69.0
½ in.	17.3	89.0	87.6	15.6	72.6	75.6
1 in.	17.6	77.6	77.0	30.0	74.0	73.0
1¼ in.	28.6	86.0	86.6	47.3	75.3	69.6
1½ in.	38.3	79.0	78.3	41.0	68.0	69.3
2 in.	38.6	68.0	70.0	39.3	61.3	59.3

The 1928 results indicate that there was one depth giving a rapid germination, and that this initial advantage was not retained, and that for the final establishment a slower germination at a shallower depth gave better results, but a depth between did not give as good a result as either. This change was already beginning to show itself by the twenty-eighth day from sowing.

The 1929 experiment.

In 1929 the bed was prepared as in 1928, but only one lot of milled seed of " common " was used, sown at six depths, each repeated three times, in five different plots from the 18th to the 22nd of April.

Counts of plants appearing above ground were taken on May 10 (eighteenth to the twenty-second day), and again from the 24th to the 27th of May (thirty-fifth day after sowing).

The plots were all cut on September 27, 1929, and afterwards the plants were counted *in situ*.

TABLE IV.

Average number of plants at each count, and the average weight of green forage per drill on Sept. 27.

Depth	¼*in.*	½*in.*	¾*in.*	1*in.*	1¼*in.*	1½*in.*
First count, May 10	54	104	172	156	167	151*
Second count, May 24-27 ...	145†	187†	231†	225	228	201*
Establishment count, Sept. 27 ...	130†	181†	217†	214	226	198*
Average weight per drill in oz. ...	19.4	23.3	26.4	26.3	26.5	22.8

* Average of twelve drills (plot 3 omitted).

† Average of four plots only, as birds pulled out the sprouts of these drills in plot 5.

It will be seen from Table IV that the ¾ in. depth gave the quickest germination by the end of the third week, but by the end of the fifth week this lead was smaller, and in the final establishment the lead was taken by the 1¼ in. depth. In all cases, and particularly for the shallower depths, the established plants showed a decrease as compared with the count on the thirty-fifth day.

When green weights of produce on Sept. 27 are considered, the heaviest yield is obtained at 1¼ in., with ¾ in. and then 1 in. very close behind.

II. Time of sowing.

It has been stated (1) that sainfoin may be sown at right angles to the corn from February to May. Local custom in the Vale of Glamorgan is in favour of April, when it is sown either under barley after roots or sometimes in autumn sown corn. Fream (2) gives April to the end of May, and Percival (3) March

and April as the best time. Wittmack (5) points out that sainfoin seed rapidly loses its germinating power even during the first year, so it can be imagined that the earlier it is sown the better are its chances. However, it is difficult with our soil and climate to get a good seed-bed before March and often barley is sown late into May. At the latter time better tilth is possible and, the weather being warmer, conditions would be more favourable to get a plant established quickly, though on the other hand there is a greater risk from insect pests.

In nature the pods are shed from July on, and lie on the surface, often partly sheltered by the parent plants or growing grass. Then the husk rots away, leaving the net a little longer and the seeds become partly fixed in the ground. Thus plants are established on railway embankments, etc., where the cover is not too thick. There has not yet been an opportunity to experiment with sowing seed in the autumn of the year in which it has been produced.

Experiments were carried out in 1926, 1927, and 1929, sowing sainfoin at different dates, the results being tested in different ways, such as by the time of first appearance, by the number of plants appearing at various intervals, or by weighing the yield of forage obtained as well as by notes on the progress of the plants from time to time.

In all these investigations there were no nurse crops.

The 1926 experiment.

In 1926 milled seed of Giant (G.2) and of " common " (C.1) and (C.2) were employed. The germination of the C.1 seed proved very unsatisfactory and C.2 was introduced at the ninth sowing date for comparison.

Each plot was 11 ft. long by 1 ft. broad, prepared by removing the soil with a spade to a uniform depth of one inch, and the seeds were sown very evenly at the rate of seventy-two per square foot (*i.e.*, 2 in. x 1 in.). Duplicate plots of both Giant and " common " were sown fortnightly from March 17 to May 18 and then weekly to July 21. The date of appearance above ground was noted, and except at the first, sixth, and seventh sowings, when the Giant appeared slightly quicker than the " common ", there was no difference between the two lots of " common " or between them and the Giant in this respect.

The date of sowing, time of appearance and cutting, and yields of Giant only are given in Table V. It appears that had the " common " seed been satisfactory, the general conclusions would be similar.

It will be seen that, except the second sowing (March 31), the sowings to the middle of May took about a fortnight to appear, and those after the end of May about a week, generally taking a day less in the latter part of May and June than in July. The second and eighth sowings gave the best " germination ".

TABLE V.

Sowing.	Date of sowing.	Number of days to appear above the ground.	Date of first cutting in seeding year 1926.	Number of days' growth to first cutting.	Weight of first cut, 1926.	Date of second cut, 1926.	Number of days' growth after first cut, 1926.	Weight of second cut, 1926.	Total days' growth to second cut, 1926.	Total weight of first and second cuts, 1926.	Weight of first cut, 1927.	Weight of second cut, 1927.	Weight of third cut, 1927.	Total weight of all cuts, 1927.
	1926	days.	1926	days.	oz.	1926	days.	oz.	days.	oz.	oz.	oz.	oz.	oz.
1st	17.3	16*	9.7	114	71	26.8	46	199	160	270	296	139	64	499
2nd	31.3	7*	9.7	100	92	26.8	46	185	146	277	327	190	139	656
3rd	14.4	14	28.7	105	98	13.9	47	137	152	235	272	118	63	453
4th	28.4	12	3.8	97	111	20.9	48	114	145	225	272	149	79	500
5th	13.5	12	11.8	90	112	21.9	41	80	131	192	226	129	66	421
6th	19.5	8	11.8	84	103	21.9	41	81½	125	184½	217	126	65	408
7th	26.5	6	11.8	77	111	21.9	41	85	118	196	248	121	59	428
8th	2.6	6	26.8	85	168	No second cut in 1926.				168	379	152	86	617
9th	9.6	6	13.9	96	163	,,	,,	,,	,,	163	310	130	72	512
10th†	16.6	6†	13.9	89	89	,,	,,	,,	,,	89	273	125	68	466
11th	23.6	7	13.9	82	90	,,	,,	,,	,,	90	199	135	60	394
12th	30.6	9	20.9	82	91	,,	,,	,,	,,	91	227	124	69	420
13th	7.7	7	20.9	75	75	,,	,,	,,	,,	75	228	127	64	419
14th	14.7	7	20.9	78	46	,,	,,	,,	,,	46	261	148	79	488
15th	21.7	7	19.10	90	38	,,	,,	,,	,,	38	208	138	70	416

* Germination was very good in both, but they were attacked by birds as coming through.

† Birds pulled out as coming through: 11th and 12th were also attacked.

In this experiment, sainfoin was cut in 1926 as it came into flower, which happens earlier, as well as more frequently, in the seeding year in the case of Giant than in the " common ". Thus the Giant was cut earlier than the " common ", sown at the same dates, and the first seven were cut again a second time.

In 1927 hay was cut on June 7 and 8, and aftermaths on August 2 and September 5.

Considering the total weights for the seeding year, the yields, on the whole, tend to decrease, as the time of sowing is delayed.

The figures for the second season (first harvest year) for the yields of the third, fourth, fifth, sixth, and seventh sowings, which were cwt twice in 1926, are low, of the eighth much larger, and then they decrease as the sowings become later. These irregularities are due partly at least to rot (*Sclerotinia Trifoliorum*), which attacked some sowings very severely after February, 1927, the damage at that time being estimated as follows :—

Sowing.	*1st and 2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*
Per cent. rot ...	15	30-40	20	15	10	5

Sowing.	*8th*	*9th*	*10th*	*11th–14th*	*15th*
Per cent. rot ...	Less than ½	1	8	Less than ½	10–15

Weather conditions after the second sowing were very good and plants were well established, giving the strongest plot throughout. The eighth and ninth sowings in June were also followed by good conditions. The first and second sowings were cut for the second time and the eighth sowing for the first time in 1926 on August 26, and made some further growth before the winter. It is probable that this has also been to their advantage in subsequent years.

The 1927 experiment.

In 1927 one lot of " common " (No. 7) 90 per cent. germination and one of Giant (No. 8) 96 per cent. germination, both milled, were sown in triplicate drills 24 ft. long, about one inch deep, from April 23. The number of seeds viable at the beginning of the season, sown per drill was, in the case of the " common " 518, and in the case of the Giant 552.

From Table VI it will be seen that in 1927 the time of appearance decreased from nine days at the end of April to about six days from the end of May to the end of July, but increased again to ten days when sowing was delayed until August. Except where birds interfered between the two counts on the fifth sowing, casualties were only recorded on the " common " sown on May 7 and the Giant sown on May 21. Unfortunately, owing to birds, the number for the earliest sowing is low, and the damage cannot be assessed. The first and third sowings were followed by cold

winds and the soil was rather wet at the time of the fifth sowing. It may be inferred from a study of the plant counts, that, given

TABLE VI.

Showing date of sowing, number of days to appear, number of days from sowing, and the average number of plants of "common" and of Giant per drill at the first and second counts, 1927.

Date of sowing	April 23	May 7	May 21	June 4	June 18	July 25	Aug. 6
Days to appear	9	8	6	6	7	6	10
1st count	May 18	May 23	June 2	June 20	July 12	Aug. 19	Sept. 1
Days' growth	25	16	13	16	24	25	27
2nd count	June 2	June 2	June 20	July 22	July 22	Sept. 1	Sept. 12
Days' growth	40	26	30	48	34	38	38
Common 1st count	352*	379	282	334	254	284	239
Common 2nd count	354*	365	355	357	215†	288	245
Giant 1st count	418*	460	423	461	437	No sowing	No sowing
Giant 2nd count	421*	463	413	472	326†	" "	" "

* Birds pulled up seedlings as coming through on May 2, and weevils were attacking the leaves on May 9.
† Birds pulled up a number of plants on July 20, just before the second count.

favourable weather and soil conditions, sainfoin may be sown up to the beginning of June, but later sowing is not safe.

Particulars of the date and yield of cuts in 1927 and 1928 ("common" only) are given in Table VII.

The last four sowings of "common" and the last three sowings of Giant had not grown sufficiently for cutting in 1927, whereas the other sowings were cut as shown in Table VII.

For the first three sowings, the evidence is in favour of early sowing, but when the 1928 figures are considered the June sowings

which were not cut in 1927 have yielded very well, but the July and August sowings have not given satisfactory results.

The 1929 experiment.

In 1929, milled seed of Eastern Counties " common " was sown at fortnightly intervals from April 22, in drills 5½ feet long,

TABLE VII.

Sown.	1927.						1928.
	Common.			Giant.			Common.
	Date of cut.	Days' growth.	Weight.	Date of cut.	Days' growth.	Total weight.	Hay and Aftermath weights.
			oz.				oz.
April 23	Sept. 1	130	314	Aug. 10	109	320	—
May 7	,, 1	116	283	Nov. 9	91		
				Aug. 10	95		
May 21	,, 12	114	194	Nov. 9	91	301	851
June 4	Not	cut	in	Aug. 24	95	116	707
June 18	,,	,,	1927.	,, 29	86	131	834
July 25	,,	,,	,,	Not	cut	in	1927. 738
Aug. 6	,,	,,	,,	,,	,,	,,	290
	,,	,,	,,	,,	,,	,,	319

at the rate of 132 seeds per drill, and repeated four times for each sowing. The drills after sowing were protected with wire netting until the plants were counted the second time.

Particulars of the dates of sowing and counting, and the average number of seedlings per drill in 1929, and date of cutting hay and aftermath and weights in 1930, are given in Table VIII.

Owing to the drier season, the plants did not make so much progress in the seeding year and therefore no cut was taken in 1929. As in the previous year, the time of sowing has more influence on the yield than on the " germination ", although the first three sowings germinated better than the following ones.

TABLE VIII.

Date of sowing.	April 22	May 6	May 21	June 3	June 17	July 1	July 15
1st count.	May 5	May 22	June 7	June 20	July 2	July 16	July 31
Days' growth	13	16	17	17	15	15	16
2nd count.	May 24	June 5	June 21	July 4	July 16	July 31	—
Days' growth	32	30	31	31	29	30	
1st count. Average plants	27	46	53	51	42	52	14
2nd count. Average plants	79	69	78	59	51	55	Not counted.
Hay cut, 12.6.30.	129 oz.	83 oz.	62 oz.	51 oz.	24 oz.	13 oz.	3 oz.
Aftermath cut, 27.8.30	65 ,,	57 ,,	59 ,,	50 ,,	45 ,,	42 ,,	20 ,,
Hay + Aftermath	194 ,,	140 ,,	121 ,,	101 ,,	69 ,,	55 ,,	23 ,,

Thus the " germinations " of the first and third sowings were practically equal, but the first sowing yielded more than double the quantity of hay in the first harvest year. Again, the final count on the fifth sowing is slightly lower than on the sixth, but the hay yield is nearly double that of the sixth.

As no cuts were taken in the seeding year, the weights in 1930 represent the results of the whole period of growth, and the earliest sowings resulted in much heavier yields of hay, each sequential sowing giving less advantage over the succeeding one. This trial shows more clearly the advantage of early sowing in the case of sainfoin, both with regard to the number of plants in the seeding year and the yield the following year.

General discussion.

In discussing the varying results of the three tests on the depth of sowing, it will be remembered that the conditions were somewhat different. In the first trial the seed-bed was a made-up soil and was very dry throughout at the beginning of the experiment, and then it was watered from above. Those conditions made for the quicker germination of the seeds at and near the surface rather than those deeper down. In the 1928 and 1929 tests, which were conducted on a garden bed, we have two contrasting seasons. The weather was drier at a later time of sowing in 1928, and consequently the deeper seeds germinated quicker than the shallower, whilst the reverse conditions obtained in 1929, when germination was quicker at the surface, the weather being moister and colder with ground frosts frequently noted at night in the period following the sowing.

In all the depth experiments with milled seed, particularly where the germination was good, some casualties were noted in the autumn count, but with the two lots of seed in the husk, casualties were not recorded, germination being slower in their case, and probably there was less competition between the plants.

On the whole, surface sowings were failures, but it will be noticed that in 1928 unmilled seed did relatively much better at the surface—possibly because of the anchorage afforded by the husk keeping the seed down so as to force the radicle into the soil, as Williams (6) found that red clover seed germinated much better at the surface when held firmly in position. These experiments throw some light on the results of field experiments with different lots in Glamorgan and Monmouthshire in 1928 and 1929. Those sown either without a nurse crop or at the same time as the spring corn became well established even when soil conditions were very dry or the tilth was not particularly good, whereas in one case under winter oats the plots were a failure owing no doubt to the difficulty of obtaining a tilth on hard dry ground, and in two other cases where the corn had been sown some months earlier in the spring, the plots were thin compared with those sown at the same time as the grain crop, but

the seeds that were in the husk gave comparatively better results than the milled, although this was hardly to be expected on the basis of laboratory germination.

The deduction is that generally sainfoin should be sown deeper than red clover, but that the exact depth depends on the condition of the soil and the season, the drier and finer the soil the greater the depth, and in all cases the seed must be well covered from ¾in. to 1¼in.

Dealing with the preliminary experiments recorded here on the date of sowing, the evidence is clear that with seed saved in the previous season, sowing should not be delayed beyond the beginning of June, but it is doubtful if, in South Wales, sowing should take place before the end of March. Early sowing gives stronger individual plants, and this tends to make up for the greater number of plants sometimes obtained from later sowings. A good deal depends on the variety, as if a second cut is taken late in the seeding year, a deleterious effect is noticed in the first harvest season. In the 1929 experiment with common sainfoin when no cut was taken in the seeding year, there is a positive correlation between the earliness of sowing and the yield of hay in the first harvest year irrespective of the number of plants established in the autumn of the seeding year.

As pointed out before, there has been no comparison between sowing late in the season in which the seed is produced and sowing in the spring of the following year, as it is difficult to obtain commercial seed before the spring.

It should also be remembered that in these trials there was no nurse crop which presumably would check development in the seeding year and obviate drastic cutting. These tests therefore indicate that " common " sainfoin should be sown as early as possible, consistent with a good tilth, but in the case of Giant without a nurse crop the cropping capacity depends not so much on time of sowing or on whether the crop is cut or not in the seeding year as on whether a vigorous plant is secured in the autumn of the seeding year. The results agree on the whole with the conclusions of Stapledon, Davies and Beddows (4) in respect of clovers and lucerne. In these sainfoin experiments the rate of sowing was much lower than that adopted by the investigators on herbage plants at Aberystwyth, and for this reason casualties from competition have not been so heavy. It is difficult to trace all casualties to their cause between fungi, pests, and the inherent vitality of the plants themselves. At the Cardiff ground, *Sclerotinia trifoliorum* has to be reckoned with particularly in the first winter, and surface caterpillars have been troublesome at

times in late summer with spaced plants, and the wireworm can do much mischief. Again, some plants are naturally shorter lived than others. No evidence of delayed germination has been obtained, but irregular growth of seedlings has been noticed.

* * *

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"SUCTION-FORCE" MEASUREMENTS ON THE SEEDS OF SOME STRAINS OF GRASSES.

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Introduction.

In 1926, Eibl (5) published the first of a series of papers directing attention to the osmotic characteristics of agricultural crop-plants and giving measurements of the suction-forces ("Saugkraft") found in their tissues. As part of his technique he germinated seeds of the plants under investigation in sand saturated with a solution of cane-sugar, and noted the effect of the latter in retarding the growth of the young seedlings. Continental workers have since determined the suction-forces of many cultivated plants by means of this method, but in a much modified form. The technique usually employed has been that developed by Buchinger (1 and 2) and consists in placing the seeds, supported between glass rods or beads, in direct contact with a series of sugar solutions of increasing concentration. The number of seeds germinating in the different solutions is found

and the solution of highest concentration in which the number of germinated seeds is at least 50 per cent. of the number germinated in water (the germination period differing with different species) is arbitrarily regarded as the " limiting concentration ". The osmotic pressure of this solution, expressed in atmospheres, constitutes the " suction-force maximum " of the species or variety investigated.

The essential principle of the method is that the osmotic activity of the sugar solution in some measure balances the osmotic and imbibitional forces present within the seed and so retards the entrance of water into the seed and more particularly into the embryo. Hence the higher the concentration of sugar solution in which germination will occur, the greater is the ability of the embryo to absorb water. Plants arising from seeds with high suction-force are claimed to be more efficient in absorbing from the soil, water and nutrient salts than those from seeds with low suction-force. As compared with the latter plants, this superiority may result in either (*a*) greater growth in the same time and under the same conditions; (*b*) equal growth under the same conditions but in a shorter time; (*c*) equal growth in the same time under less favourable conditions or (*d*) a combination of these characteristics in greater or less degree (Hafekost).

Eibl (6) found that in wheat and rye a high suction-force was associated with a short period of growth and Sandu-Ville (19) and Pop (16), employing the technique described above, found the same correlation between high suction-force and early maturity to exist in legumes and wheat.

High suction-force in the seed-embryo has been found to be correlated with high crop yields in strains of sugar beet by Hafekost (7) and in wheat and rye by Konopa (10). Further cases are referred to by Buchinger (4) in a paper giving a general review of the present subject. An association has also been found by some workers between suction-force and winter-hardiness and drought-resistance, these latter properties apparently being determined in some measure by the same factors. Sandu-Ville (20) found that varieties of *Panicum miliaceum* and *Setaria germanica* from a dry district had higher suction-force maxima than those from humid districts.

Meyer (12) has criticised the method on the grounds that germination is not only an osmotic process but that the materials present in the endosperm also play an important rôle; he believes, therefore, that far-reaching conclusions as to ecology cannot be drawn from such tests, but that they are nevertheless

a valuable aid to the estimation of seed-value. The same worker (11) has also found that the behaviour of seeds of cereals in sugar solutions is not only determined by the conditions of soaking but also by the environment under which the seeds developed. Buchinger (4), however, denies that the latter can have any permanent effect on the suction-force of the seedling or variety, and the results obtained by Konopa (10) support this view.

A serious technical difficulty met with in these determinations is the development of fungi in the sugar solutions, which, as a consequence, become acid in reaction, to a degree differing with different concentrations, those around 0.4N—0.6N acidifying most rapidly. The addition of formaldehyde to the sugar solutions for the purpose of checking fungal growth has been tried, but Rathsack and Schunemann (18) found that it in no way hindered acidification. Pammer (15) found that fungal growth was checked but not inhibited by the addition of 0.05 per cent. formalin and 0.1 per cent. sodium bicarbonate; renewal of the solution did not become necessary until after four to six days, whereas it was required after two days with sugar alone. The added chemicals did not adversely affect the germination of barley.

Pammer (13) has determined the suction-force maxima of a large number of grasses and clovers. He found that cultivated species of grasses (*e.g.*, *Lolium perenne*) had higher maxima than uncultivated grasses (*e.g.*, *Bromus* spp.). Species which occur naturally in heavy soils were found to be characterised by high suction-force, those occurring in light soils by low. Seed from wild *Medicago lupulina* gave a lower suction-force maximum than that from cultivated strains, and Hueber (8) has found a somewhat similar position with wheat and rye, the bred strains having higher suction-force than the "land" types.

The technique described above is not the only one providing insight into the suction-force of seeds. Rathsack and Meyer (17) have described a method differing in detail but not in principle. It is, however, possible to compare the suction-forces of different seeds by noting the rapidity of germination in the sugar solution, those seeds having a high suction-force germinating earlier than those with low. This principle underlies the ingenious method used by Pammer (14) for selecting plants of grasses and clovers with high and low suction forces. Seeds were germinated in 0.1N and 0.3N sugar solutions occurring in the higher concentration only by the third day. All seeds germinating earlier than

this in the 0.1N solution were discarded, but those in which germination occurred simultaneously with the earliest in the 0.8N were grown on together with the latter and under similar conditions. In this way plants characterised by two extremes of suction-force and of exactly the same age were obtained. In *Festuca rubra*, *Alopecurus pratensis*, *Dactylis glomerata* and *Phleum pratense*, the individual plants arising from seeds with high suction-force gave yields higher by 39-85 per cent. than those of the plants with low suction-force, the differences in cocksfoot and timothy being especially pronounced. Employing a similar method Buchinger (3) obtained higher yields from wheat plants developed from seeds possessing high suction-force.[1]

There have been developed at the Welsh Plant Breeding Station strains of grasses characterised by different types of growth and differing particularly markedly in growth-development from the strains obtainable commercially.[2] The results described by Pammer suggested to the present writer the desirability of determining whether these " indigenous " strains differed at all in regard to suction-force from the commercial strains, as on the basis of Pammer's results one would expect them to do. The results described below are from some experiments of a quite preliminary nature which have been carried out in order to gain some insight into this question and to acquire a little acquaintance with this line of investigation.

Materials and methods.

Most of the experiments described in this paper have been carried out on seeds of timothy (*Phleum* spp.), but a few results obtained with seeds of Italian rye-grass (*Lolium italicum*) and perennial rye-grass (*Lolium perenne*) are also described.

The quickness of germination which characterises timothy seed makes it particularly suitable for experiments concerned with germination in sugar solutions, since the effects of fungal growth occurring in the latter are lessened in proportion as the duration of the experiment is shortened. Moreover, there were available to the writer several " indigenous " strains of this grass, which, while not pure-lines were sufficiently closely bred for the majority of the plants within them to possess certain characteristics peculiar to each particular strain. Of those used in the present case, Bd 326 is an exceptionally late flowering

[1] The above review of the literature of this subject has been made rather extensive, since, so far as the writer is aware, no work of this kind has been published up to the present in any English scientific journal.

[2] The indigenous seed used in the present experiments was of strains which in every case have been developed by Mr. T. J. Jenkin, M.Sc.

type, having shoots which are extremely prostrate in growth and which root at the nodes under certain conditions; Bd 324 is similar to the foregoing, but differs in having a more upright growth, in having finer leaves and in flowering earlier; it originated from plants growing in a drier habitat than those which gave rise to Bd 326. Both strains are dense in growth, multi-tillered and better suited to pasture than to hay conditions.

Bd 352 is a strain having very different growth-characteristics from the above, conforming rather closely to the ordinary commercial type; flowering occurs earlier, the leaves are broader and larger, and the growth is more upright and vigorous than in the two preceding strains. Indeed, there is a possibility that the latter belong to a different species of timothy from Bd 352 and the commercial strains.

Bd 352 is later in flowering than " commercial " timothy.

The strain Ba 1752 of perennial rye-grass is again a type suited for growth in pasture; it is later in flowering, slower in early growth, and more prostrate in habit than the commercial strains.

Bb 187 has been selected for the property of greater leafiness as compared with the strains at present on the market. Flowering occurs at about the same time as with the latter types, but growth is probably more rapid in this strain, which, like Bd 352, is a suitable constituent for swards laid down to hay. It is, however, unfortunate that no exact data as to the growth-rates of any of these strains are at present available.

The samples referred to below as " commercial " have been obtained from a reputable firm of seedsmen and can probably be regarded as typical of the strains available in the trade.

For such early experiments as those the results of which are described in this paper, it was desirable to employ a technique as simple as possible. " Suction-force maxima " have not therefore been determined, the rapidity of germination in the sugar solutions being taken as an index of the suction-forces of the seeds of the different strains.

The sugar solutions were made up with distilled water and measured into small (9 cm. diameter) Petri dishes, 20 cc. being placed in each dish. Two hundred seeds were floated on the surface of this liquid in each case, and in any experiment the seeds of a single strain were placed in three dishes of each particular solution, the experimental unit being, therefore, 600 seeds. All the dishes in any one experiment were kept under uniform conditions.

If they are not disturbed, grass seeds will float on the surface of water or a solution of sugar until long after germination has occurred, but in the present experiment, in making the germination-counts, the germinated seeds were removed and this disturbance caused a large number of seeds to sink underneath the liquid. After the first two or three counts, therefore, the results are possibly subject to error on this account. Any effect at this stage, however, is probably subordinated to that arising from increasing fungal growth in the medium with the progress of the experiment. From these considerations, significance is only attached to the results of the earlier counts.

In some experiments, the solutions were frequently changed by removing the old solution with a pipette and substituting fresh solution of a corresponding concentration. It was found, however, that this operation did not prevent the acidification of the solutions, and had the disadvantage of disturbing the seeds.

TABLE I.

Showing the detrimental effect of sodium bicarbonate and formalin solution on germination of grass seeds. (Temperature = 21°C).

	Distilled water.			*Average per cent.*	*1 per cent. $NaHCO_3$ and 0.5 per cent. formalin.*			*Average per cent.*
Germination of timothy (Bd. 352).	(*a*)	(*b*)	(*c*)		(*a*)	(*b*)	(*c*)	
After 4 days	141	148	173	77	68	98	80	41
After 10 days	153	167	198	86	103	141	108	59
Germination of cocksfoot (Bc. 1168).								
After 10 days	58	66		21	1	5		1

Only pure sugar solutions were employed, without the addition of any form of disinfectant. The results given in Table I show clearly that the presence of formalin and sodium bicarbonate, in the concentrations recommended by Pammer (15), is markedly inimical to the germination of grass seeds. In this experiment cocksfoot seed was introduced, since on account of its extremely slow germination it is unsuitable for germination in sugar solutions unless fungal growth can be inhibited. The latter effect, however, was not obtained from the addition of the chemicals.

The solutions used fall into two series (*a*) Distilled water, 0.1N cane-sugar solution (= 3.4 per cent.), and 0.3N sugar solution (= 10.2 per cent.): and (*b*) 1 per cent. (= 0.08N);

8 per cent. (=0.09N) and 5 per cent. (=0.15N) cane-sugar solutions.

Results.

The germination figures obtained with seeds of timothy are shown in full in Tables II, III, and IV; the range of variation of the counts made on the same sort of seed in the same concentration of sugar solution is fairly wide in each experiment, but is probably satisfactory on the whole. In accordance with what has been said above, the counts made later than five days from the commencement of the experiment are in each case disregarded for the purpose of comparing the different samples of seed.

TABLE II.

Showing (1) germination of timothy seed in distilled water and 0.1N. and 0.3N solutions of cane sugar; and (2) the alteration in hydrogen-ion concentration of the solutions during the experiment. (Temperature=20°C.).

	Distilled water.			*Average per cent.*	*0.1N sucrose solution.*			*Average per cent.*	*0.3N sucrose solution.*			*Average per cent.*
Germination after three days.	(*a*)	(*b*)	(*c*)		(*a*)	(*b*)	(*c*)		(*a*)	(*b*)	(*c*)	
Commercial timothy ...	106	107	113	54	86	85	81	42	36	43	36	19
Bd 326	51	41	40	22	28	20	17	11	15	8	6	5
Bd 324	53	62	60	29	23	19	23	11	8	5	6	3
Bd 352	66	61	70	33	12	20	25	9.5	9	4	6	3
Germination after four days.												
Commercial timothy ...	140	140	152	72	125	135	119	63	80	79	78	39.5
Bd 326	83	73	66	37	51	39	33	20.5	24	18	11	9
Bd 324	121	122	113	59	49	42	53	24	11	8	11	5
Bd 352	121	110	128	60	28	45	43	19	15	7	13	6
Germination after five days.												
Commercial timothy ...	164	166	167	83	145	156	147	75	114	117	112	57
Bd 326	102	120	100	54	81	63	52	33	38	30	29	16
Bd 324	157	155	159	78.5	81	75	93	41.5	28	21	30	13
Bd 352	133	138	143	69	54	80	71	34	42	21	32	16
Reaction of solutions after three days.		pH				pH				pH		
Bd commercial	6.3	6.3	6.3		5.9	5.8	< 4.4		4.2	4.2	4.3	
Bd 326	6.4	6.4	6.5		3.8	3.8	3.8		3.7	3.7	3.7	
Bd 324	6.3	6.3	6.3		< 4.0	3.8	3.8		3.8	3.8	3.8	
Bd 352	6.5	6.5	6.5		3.6	4.0	3.8		3.8	3.8	3.7	

Reaction after nine days (solutions having been changed three times): Distilled water pH 5.9; 0.1N sucrose solution pH 3.0-pH 4.9; 0.3N sucrose solution pH 3.4-pH 4.2.

Reaction of 0.3N sucrose without any seeds=pH 4.5.

Reaction at commencement was pH 6.2 in all cases.

The results shown in Table II are from an experiment in which the solutions were changed after making the first germination count on the third day and on each alternate day subsequently. The germination of the commercial sample shows a marked superiority over that of all the indigenous strains, but the differences within the latter are not so well defined. The germination percentages in themselves show very little variation for the three strains, but if the germination in the sugar solutions is related to that in distilled water the ratio of the former to the latter is highest in commercial timothy, followed at a very considerable interval by Bd 326. The strains Bd 324 and Bd 352 show the lowest ratios with no significant difference between them.

TABLE III.

Showing (1) germination of timothy seed in distilled water and in sugar solutions, and (2) the reaction of the solutions.

	Distilled water.			*Average per cent.*	0.1*N* *sucrose solution.*			*Average per cent.*	0.3*N* *sucrose solution.*			*Average per cent.*
Germination after four days.	(*a*)	(*b*)	(*c*)		(*a*)	(*b*)	(*c*)		(*a*)	(*b*)	(*c*)	
Commercial timothy ...	138	146	137	70	119	118	127	61	58	52	46	26
Bd 326	65	78	68	35	50	47	38	22.5	14	19	22	9
Bd 324	100	96	98	49	24	44	32	16.5	5	9	16	5
Bd 352	110	96	104	52	64	70	36	28	12	9	13	6
Germination after five days.												
Commercial timothy ...	151	154	143	74.5	133	141	135	68	100	97	84	47
Bd 326	79	93	84	42.5	56	61	52	28	28	32	26	14
Bd 324	114	116	116	57.5	54	73	54	30	13	21	26	10
Bd 352	117	106	118	57	83	96	63	40	30	22	21	12
Germination after seven days.												
Commercial timothy ...	159	161	154	79	143	149	143	72	120	128	114	60
Bd 326	103	111	123	56	60	68	60	31	39	48	43	21.5
Bd 324	164	167	161	82	69	91	70	38	30	47	45	20
Bd 352	127	114	126	61	92	103	68	44	52	45	39	22.5
Reaction after five days.		pH				pH				pH		
Bd commercial	6.3	6.3	6.2		4.0	3.5	3.5		3.5	3.5	3.5	
Bd 326	6.5	6.3	6.3		3.1	2.8	3.2		3.3	3.3	3.3	
Bd 324	6.3	6.3	6.3		3.2	3.4	3.1		3.3	3.4	3.5	
Bd 352	6.4	6.4	5.6		3.1	3.5	3.0		3.3	3.3	3.3	

Reaction of 0.1N sucrose without seeds (after five days)—(*a*) pH 5.9 and (*b*) pH 5.5
Reaction of 0.3N sucrose without seeds (after five days) (*a*) pH 5.9 and (*b*) pH 5.9.
Reaction at commencement was pH 5.9 in all cases.

The percentages of germination up to the fifth day are much lower with all the samples in sugar solution than in distilled water, and indeed a concentration of 1 per cent. sucrose (0.08N) is sufficient to depress appreciably the germination of the indigenous seed.

The figures respresentative of the hydrogen-ion concentrations in Tables II and III show how markedly acid in reaction the sugar solutions become. It is noteworthy that with seeds germinating in distilled water alone the alteration is quite negligible, and in the direction of alkalinity, this last alteration probably being caused by the glass of the Petri dish; also the seeds themselves are indirectly responsible for the low pH values in the sugar solution, since in the latter alone acidification is much less (*cf.* also Table III). The reason for this is not altogether clear, since considerable fungal growth occurs in the solution without seeds, and any effect due to the respiration of the latter must be negligible. The values given in Tables II and III show also a slight difference in reaction between the solutions in which the germination of commercial timothy took place and those in which germination of the indigenous strains occurred. Since in the latter more seeds remained in the solution during the experiment than was the case with the former, it is possible that the acidity results from the growth of fungi on the tissue of the seeds in the presence of the sugar. A further possibility is that the difference is due to different fungi being carried by the different samples. In any case the disadvantage attached to the use of sugar solutions on this account is clear; nor can this be overcome by sterilization of the seeds before use, since in this operation there is always the very probable danger of injury to the seeds themselves and in a differential degree with the different samples. The detrimental effect on germination of sugar solutions in which germination has occurred is very plainly shown by the results given in Table V. In this experiment seeds of the four strains of timothy were germinated in distilled water and in freshly prepared 1 and 5 per cent. sucrose, and also in similar solutions in which a germination test on the same seeds had already been carried out over a period of fourteen days, during which time, however, the solutions had been changed three times. The latter solutions, therefore, have the disadvantages resulting from fungal growth present in an extreme degree.

It will be seen that whereas germination in the old distilled water is only slightly less than in the fresh, the diminution in the old lots of sugar solutions is very great; it is not, however,

the same with all the samples, the commercial seed being less affected by the adverse conditions than the indigenous seed. While it is true that in the solutions in which the commercial seeds germinated these conditions would be somewhat less pronounced since the seeds previously germinated in them were

TABLE IV.

Showing the germination given by the seed of three strains of timothy in 1, 3, and 5 per cent. solutions of cane sugar. (Temperature about 17°C).

	1 per cent. sucrose solution.			Average per cent.	3 per cent. sucrose solution.			Average per cent.	5 per cent. sucrose solution.			Average per cent.
	(a)	(b)	(c)		(a)	(b)	(c)		(a)	(b)	(c)	
Germination after four days.												
Commercial timothy ...	122	116	123	60	91	103	92	47.5	82	73	77	38.5
Bd 324 ...	34	27	31	1.5	10	7	13	.5	8	7	11	4
Bd 352 ...	97	83	87	44.5	17	35	30	13.5	44	32	47	20.5
Germination after five days.												
Commercial timothy ...	167	165	160	82	153	150	165	78	154	147	137	73
Bd 324 ...	86	61	75	37	68	49	68	31	23	31	31	14
Bd 352 ...	123	125	134	63.5	76	95	67	39.5	81	80	87	41
Germination after nine days.												
Commercial timothy ...	175	176	177	88	176	177	181	89	172	178	163	85.5
Bd 324 ...	126	86	102	52	90	97	109	49.5	79	75	65	36
Bd 352 ...	140	141	148	71.5	129	146	106	73.5	132	130	111	62

commercial (and it has been seen that the reaction of such solutions is slightly less acid than in the solutions with indigenous seeds), these figures provide evidence for the existence of a further factor affecting the results of these tests, namely, the specific resistance of the seed sample to the inimical factors arising from fungal growth in the sugar solution.

Experiments carried out with sulphuric acid on the germination of grass seeds suggest that while the acidity developed in an extreme case such as the above is sufficient in itself to diminish germination, that arising normally is not likely to be detrimental. It is extremely probable, however, that the products of fungal growth in the sugar solutions have a toxic action on the germinating seeds.

The results given in Table III are from an experiment in which the solutions were not changed at all. Here again the commercial seed is the only sample to give an appreciable early germination in the 0.3N sucrose solution, and its superiority over the indigenous strains is again evident in the 0.1N solution. When it is remembered that the germinated seeds selected by Pammer (14) for high suction-force were taken from a solution

TABLE V.

Showing germination in fresh solutions and in solutions in which seeds had been germinating for fourteen days previous.

	Distilled water.		*1 per cent. sucrose solution.*		*5 per cent. sucrose solution.*	
	Per cent.		*Per cent.*		*Per cent.*	
	New.	*Old.*	*New.*	*Old.*	*New.*	*Old.*
Germination after four days.						
Commercial timothy	72	68	63	46	49	31
Bd 326 ...	29	21	26	4	14	0
Bd 324 ...	42	34	23	6	4	6
Bd 352 ...	54	38	46	2	32	6
Germination after eight days.						
Commercial timothy	91	87	83	71	72	54
Bd 326 ...	73	68	52	7	32	11
Bd 324 ...	85	83	70	25	50	23
Bd 352 ...	62	59	60	4	44	15

of this concentration so early as on the third day, there can be little doubt that the plants resulting from them were of the "commercial" type. The vigorous early growth which characterises this type is in agreement with the description given by Pammer of the growth of his selected plants. Such a growth is no doubt highly desirable for the purposes of continental agriculture, but it has been shown that lack of persistence of such plants reduces their suitability for British pastures.

If the ratio between the germination in sugar solution and that in distilled water is again taken as a measurement of the suction-force of the strain, the figures in Table III again place

that of Bd 326 nearest to that of the commercial strain, but there is further, a superiority shown, of Bd 352 over Bd 324.

The greater vigour in germination of commercial seed over indigenous and of Bd 352 over Bd 324 is again made clear in Table IV.

If one compares the results of the above experiments with those given by an orthodox germination-test on these samples of seed (*cf.* Table VI), it will be seen that there is no relation between the former and either the germination percentages or the " energy of germination " figures obtained in such a test.

TABLE VI.

Showing germination under usual conditions of a germination test (i.e., on moist filter paper and with alternating temperatures).

	Germination after fourteen days. Per cent.	*" Energy of germination." Per cent.*
Commercial timothy	82	78
Bd 326 ...	65	57
Bd 324 ...	82	74
Bd 352 ...	87	79

The behaviour of rye-grass seed in solutions of sugar is shown in Table VII. With these grasses also the germination of the commercial strains is far less affected by the sugar than that of the indigenous samples which is much depressed; there is, likewise, here, no relationship perceptible between the figures of germination in these solutions and those obtained in a germination test carried out in the usual way (*cf.* Table VIII). The latter figures are not available for commercial *Lolium italicum*, but the extreme difference between the germination of that sample and that of Bb 187 in sugar solution, and the low value of the latter as compared with the normal germination of Bb 187, make them unnecessary.

If one compares the results obtained with those that one would have forecasted from a knowledge of the growth-habit of these strains, one finds no similarity between them. One would have expected the suction-forces of the timothy seeds to have been, in order of magnitude, commercial timothy, Bd 352, Bd 324, and Bd 326; actually the last comes second. Again, Bb 187 would have been expected to give a similar result to the commercial seed, whereas that observed is quite different.

TABLE VII.

Showing the germination of Italian and perennial rye-grasses in sugar solutions. (Temperature about 16°C.).

	1 per cent. sucrose solution.			Average per cent.	3 per cent. sucrose solution.			Average per cent.	5 per cent. sucrose solution.			Average per cent.
Germination after four days.	(a)	(b)	(c)		(a)	(b)	(c)		(a)	(b)	(c)	
Commercial *Lolium perenne*	15	30	27	12	22	25	28	12.5	17	11	21	8
Ba 1752	2	3	4	1.5	11	10	14	6	10	6	11	4.5
Commercial *Lolium italicum*	160	157	157	79	150	140	133	70.5	146	137	156	73
Bb 187	30	44	44	20	26	35	41	17	27	29	48	17
Germination after eleven days.												
Commercial *Lolium perenne*	48	63	47	26	50	58	56	27	49	44	54	24.5
Ba 1752	48	64	65	29.5	49	63	66	30	53	62	48	27
Commercial *Lolium italicum*	189	171	164	87	164	154	153	78.5	158	155	176	81.5
Bb 187	47	75	89	35	81	100	98	46.5	79	89	106	46

TABLE VIII.

Showing the germination of perennial and Italian ryegrass under the conditions of a normal germination test.

	Germination. *Per cent.*	"*Energy of germination.*" *Per cent.*
Commercial *Lolium perenne* ...	61	55
Ba 1752 ...	65	60
Bb 187 ...	79	78

Discussion.

The experiments described above are too few in number to enable one to draw far-reaching conclusions from them, but they raise several interesting questions.

The consistently higher suction-force found for the commercial seed as compared with the indigenous suggests the possibility of using germination tests in sugar solution as a diagnostic in identifying any given sample of seed; and if reliable such a diagnostic would be of extreme value.

It is, however, evident that the few results obtained so far with the indigenous strains show no indication of any correlation between the suction-force and the growth-habit of a strain.

Meyer has drawn attention to the value of germination tests in sugar solutions in estimating the vigour of a sample of seed, and Buchinger has expressed agreement with his remarks. The results given above show that the method is a very convenient one for this purpose, but if, as Buchinger maintains, the suction-force of a strain is specific and constant, the application would be limited almost entirely to samples which were not genetically pure. In this connection it may be pointed out that Jones and Tincker (9), working with genetically pure material, found that in oats seed-vigour was correlated with yield. The technique used in estimating the former quality was very different from the one at present under review, and it is probable that the results obtained hold no relationship to those derived from sugar solutions; it is, however, only fair to point out that the differentiation obtained by Pammer by means of such solutions may possibly be explained along similar lines.

It is hoped to carry out further experiments with a view to obtaining some insight into these matters.

Acknowledgments.

It is a pleasure to acknowledge the kindly interest of Professor R. G. Stapledon, under whose direction the work has been carried out. The thanks of the author are also due to Mr. T. J. Jenkin for the description of the indigenous strains given herein, and to the members of the staff of the Imperial Bureau of Plant Genetics for assistance with the literature.

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SIMPLE SEEDS MIXTURES CONTAINING PEDIGREE AND INDIGENOUS STRAINS COMPARED WITH ORDINARY COMMERCIAL MIXTURES FOR PERMANENT GRASS.

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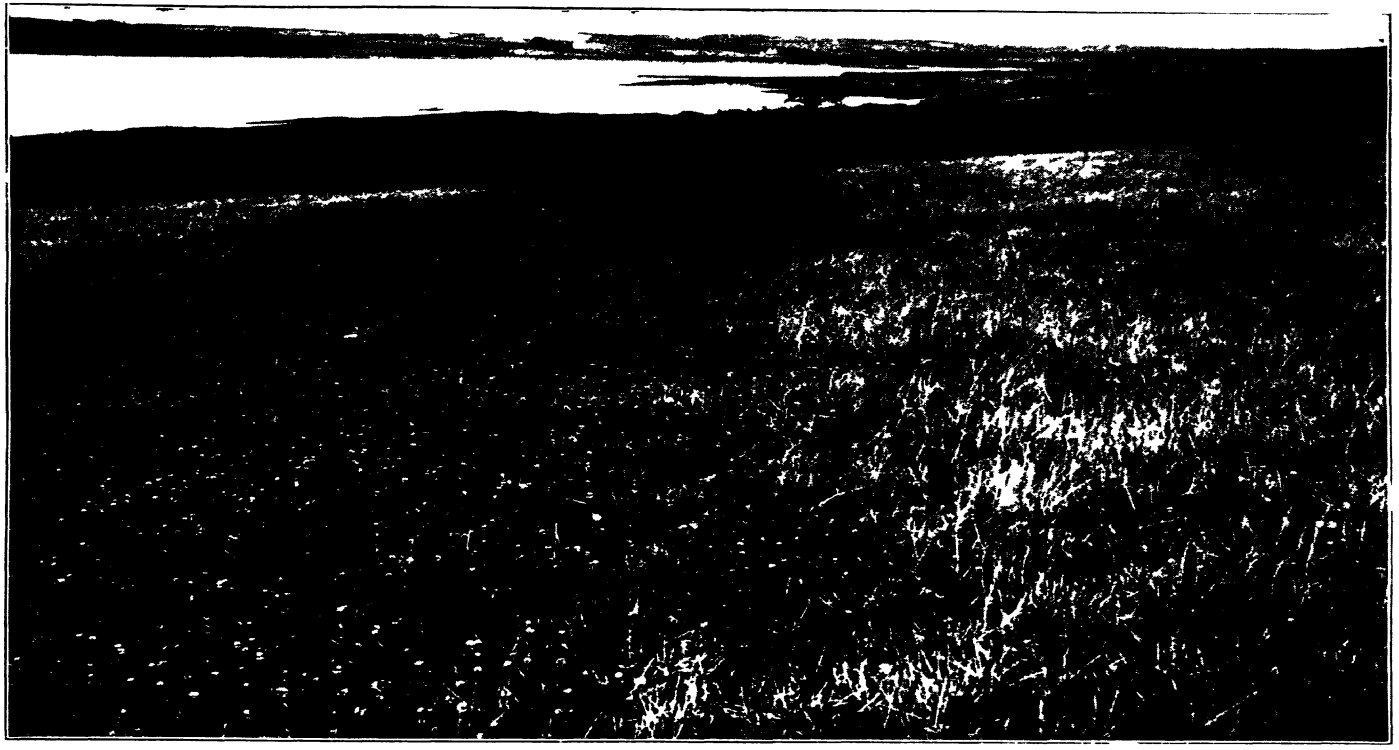
Introduction.

Evidence of the importance of suitably blended simple mixtures in the formation of permanent pastures has been accumulating steadily at the Welsh Plant Breeding Station for



A "simple mixture" plot on left (see Table I, Mixture I) compared with the farmer's mixture on right. Note the wealth of wild white clover on the former plot, and the mass of burned, ungrazed herbage on the latter.

several years and although a certain percentage of farmers realise this fact there are still large numbers who allow the price of the mixture per acre to be the dominating factor in their choice of seed.

The present paper deals with the advantages gained from suitable seedings of simple mixtures containing pedigree and indigenous strains of grasses compared with the ordinary commercial type of mixture generally used by farmers in Mid-South Wales.

Material and methods.

In the spring of 1928 one-tenth acre strips were sown in the same field as the farmer's mixture at eight to ten centres in each of the following counties :—Brecon, Cardigan, Carmarthen, Merioneth, Montgomery, and Pembroke. Each field was managed by the occupant farmer himself in his own way.

The fields were laid down under a cereal nurse and the analyses carried out during the summer of the second harvest year—1930. At most of the centres hay was taken for two years and in all cases both the experimental plot and the farmer's mixture were managed in a similar manner.

The analysis was carried out on most of the plots very soon after the hay had been harvested and at a time, therefore, when a pasture plant like wild white clover was not at its best. At centres where the hay had not been harvested at the time of our visit random samples were taken on the experimental plot and on a similar sized area of the farmer's mixture. These samples were subjected to botanical analysis. The composition of the seeds mixtures is shown in Table I.

The mixtures sown on the experimental plots were designed, as far as possible, to suit specific conditions, evidence obtained from previous trials on similar lines being utilized in compounding them. Mixtures I and III were adapted for more fertile conditions, and Mixture II for poorer and upland conditions.

In regard to several of the experimental plots and from information obtained from the farmers concerned, it should be stated that they were more heavily grazed than was the general body of the field. This is to be attributed in part to the greater leafiness of the strains, and in part to their slower rate of growth as compared with the commercial strains, as a result of which the pedigree and indigenous strains are in a more convenient stage of growth for grazing purposes when the animals are turned into the field. The accompanying photograph shows the marked difference between the experimental plot and the remainder of the field.

TABLE I.

Showing details of seeding per acre of the plot mixtures.

Species and strain.	*Mixture in lb. per acre.*		
	I.	II.	III.
Italian rye-grass	6	6	6
Perennial rye-grass (indigenous)	14	0	14
Cocksfoot (pedigree)	0	16	0
Rough-stalked meadow grass ...	4	4	4
Crested dogstail	4	4	0
Montgomery red clover	4	4	4
Wild white clover	3	3	3

Discussion of results.

The figures in Table II indicate clearly the marked superiority of the experimental plots. The pedigree and indigenous strains persist and fill the ground better and suppress weeds far more efficiently than the adjacent farmer's mixture. The inclusion of rough-stalked meadow grass, crested dogstail and wild white clover seems fully justified and these species should help, under good management, to maintain a weed-free sward for several years. Although the figures represent the average of a number of centres, each individual plot showed itself to be better than the adjacent farmer's mixture.

TABLE II.

Showing the percentage contribution of sown grasses, clovers and weeds and the percentage of bare ground. Analyses on the tiller estimation basis (1).

	Sown grasses.	*Red clover.**	*White clover.*†	*Unsown grasses.*‡	*Miscellaneous weeds.*	*Percentage bare ground.*
Experimental plots	69.2	3.9	14.3	8.8	3.8	7
Farmer's mixture	50.9	1.2	8.1	25.7	14.1	16

* Experimental plot = all Montgomery red.
Farmer's mixture = at some centres Montgomery red, but very often broad red only.

† Experimental plot = wild white clover.
Farmer's mixture = generally Dutch white clover.

‡ Mainly bent and Yorkshire fog.

In Table III the figures show botanical composition of hay samples taken at some centres where on account of weather conditions the hay had not been cut at the time of our visit. The

superiority of the experimental plots is further exemplified by these average figures.

TABLE III.

Showing the percentage contribution of sown grasses, clovers and weeds as hay. Analyses on the percentage productivity estimation basis (1).

	Sown grasses.	*Red clover.*	*White clover.*	*Unsown grasses.*	*Miscellaneous weeds.*
Experimental plot	72.0	12.9	3.9	7.4	3.8
Farmer's mixture	49.4	7.5	3.6	21.4	18.1

It was evident from the detailed analyses of the commercial mixtures that some of the species sown by the farmer were already almost non-existent. Farmers persist in sowing small amounts per acre of several species, and these in competition with larger seedings of the more aggressive species must suffer. This applies particularly to meadow fescue, which in competition with the rye-grasses has practically no value. Money can be used to better advantage by increasing the seeding of the species that do well and excluding the other species altogether (2). Farmers are also apt to use too much Italian rye-grass : this species which is useful for providing spring keep during the first year is, however, short-lived and contributes but little in subsequent years. As a hay plant Italian rye-grass has a detrimental effect on the other more slow-growing constituents of a mixture. As a pasture plant it is invaluable for spring grazing. The amount sown per acre should be regulated in accordance with the duration of spring grazing : in the case of early enclosure for hay a seeding of 2 lb. per acre is sufficient, but if grazing is to be continued intermittently to the end of April, a seeding of 5 lb. would have no deleterious effect on the ultimate sward.

There is a tendency also to use too little cocksfoot, especially in the poorer upland districts, where, in many cases, it should be the dominant ingredient in a mixture.

It is highly important in any seeds mixture to include an adequate seeding of each constituent species.

Pedigree strains of cocksfoot and perennial rye-grass are not yet available on a commercial scale. These have always given better results than any other strains tested. Until these strains are on the market, farmers are advised to use in their mixtures New Zealand cocksfoot and perennial rye-grass from wild white

clover cleanings, as they are more leafy and persistent than ordinary commercial strains. The persistency and general value of Montgomery red clover and wild white clover have been demonstrated on several occasions (3; 4).

The type of seeds mixture given below should meet the needs of a large number of farmers in Wales for fields put down to grass for three years or longer. It should provide hay for one or two years and pasture for some years subsequently.

	Lb. per acre.
Italian rye-grass	3
Perennial rye-grass (*ex* wild white clover cleanings)	12
New Zealand cocksfoot	10
Rough-stalked meadow grass	2
Crested dogstail	2
Montgomery red clover	4
Wild white clover	2

Commercial timothy is useful for hay during the first year or so, but, generally speaking, it is not a valuable ingredient.

Conclusions.

(1) The value of simple mixtures containing pedigree and indigenous strains of grasses has been discussed.

(2) These mixtures are proving to be superior to the farmer's mixture when sown in the same field, although in some cases they are more heavily grazed.

(3) They persist and hold the ground better and suppress weeds more efficiently than does the farmer's mixture.

Acknowledgments.

I am indebted to Professor R. G. Stapledon, M.A., for his kind interest and help, and to Mr. William Davies, M.Sc., who initiated the experiment. Thanks are also due to the county agricultural organizers concerned for arranging the centres for experimentation, and to the farmers on whose land the plots were laid down for their very willing co-operation.

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THE EFFECT OF SOWING WILD WHITE CLOVER ON THE MEAT PRODUCING CAPACITY OF A TEMPORARY PASTURE.

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Object of Trial.

Critical experimental work (1) carried out in North Wales has shown that the inclusion or omission of wild white clover in a seeds mixture has an important effect on the quality of the pasture, as judged by botanical composition, even at the end of seven years. This trial was carried out to test whether the inclusion of this ingredient in the seeds mixture results in increased meat producing and stock carrying capacity of the pastures, and, if so, to gauge the extent of the gain under the particular conditions.

Plan of Trial.

An eight acre field of a fairly uniform nature was laid down to grass at the College Farm of the University College of North Wales, Bangor, in 1927. The nurse crop was oats and the whole field was sown with the following mixture :—

Italian ryegrass	4 lb.	per acre.
Perennial ryegrass	12 lb.	per acre.
Wild perennial ryegrass	8 lb.	per acre.
Cocksfoot	5 lb.	per acre.
Timothy	6 lb.	per acre.
Rough stalked meadow grass	1 lb.	
Vale of Clwyd red clover	5 lb.	

In addition, on one half of the field 1 lb. per acre of wild white clover was added to the above mixture, so that two plots of four acres each were obtained, similar in previous cropping and manuring, and similar in seeding except that wild white clover was included in the seeding of one and omitted from the other. The two plots were not separated, and received the same treatment as regards cropping and grazing up to the commencement of the trial, May 9, 1930. A hay crop was taken in 1928 and 1929, and the plots received a light dressing of farmyard manure in the winter of 1928-9. The field was grazed with sheep, which were given roots to supplement the grass, during the winter of 1929-30, and when they were turned off on April 21, 1930, the whole field was uniformly very bare. A fence was then erected to separate the two plots, both of which were well supplied with clean water.

Stocking of plots.

On May 9, twenty Welsh mountain ewes, each with one lamb were turned into the wild white clover plot, and sixteen similar ewes, each with one lamb, were turned into the other plot, the ewes and lambs having been weighed beforehand. The ewes and lambs were selected after weighing, the two lots being so made up as to be as similar as possible except in respect of numbers. The lambs were by rams of the same breed as the ewes, and were dropped the last week in March and the first week in April. On May 12, four heifers, two Welsh Black and two Shorthorn, and all from ten to twelve months old, were put into each plot, the same care being exercised to get the two lots as uniform as possible, as in the case of the sheep. On July 5, all the stock was removed from the plots, most of the lambs being disposed of to a butcher; from July 5 to July 10 both plots were free of all stock. The two lots of four heifers that had occupied each plot for the first half of the trial were turned on to the same plots on July 10 and remained on these plots until October 17. On July 29, twenty Welsh mountain wether lambs were

TABLE I.

Stock carried May 9—October 17.

Date when stock turned in.	*Plot A (¼ acres). Wild white clover sown.*		*Plot B (¼ acres). No wild white sown.*	
		Av. weight start of period.		*Av. weight start of period.*
PERIOD 1.				
May 9–July 5	20 ewes.	69 lb.	16 ewes.	70 lb.
do.	20 lambs.	30 lb.	16 lambs.	30 lb.
May 12–July 5	4 heifers.	471 lb.	4 heifers.	460 lb.
PERIOD 2.				
July 10–October 17	Same 4 heifers.	544 lb.	Same 4 heifers.	528 lb.
Aug. 1–October 17	2 additional heifers.	693 lb.	—	—
July 29–August 28	20 lambs.	50 lb.	12 lambs.	50½ lb.

put on to plot A and twelve similar ones on to plot B, these being lambs which, instead of having been turned up the mountain after shearing, were weaned and kept on the low ground. At this date, July 29, there was sufficient "food" on both plots, though considerably more on plot A. The preponderance of grass on plot A was such that on August 1 two additional heifers were turned on to this plot. Although this plot was more heavily stocked than plot B, there was during the whole of the second

period, as there was during the first period, more grass on plot A; there was a tendency for the superiority of the stock carrying capacity of the latter to become more marked as the season advanced. Table I shows the stocking of the plots during the season. From May 9 to July 5, plot A carried one ewe and one lamb per acre more than plot B, the number of cattle being the same on both. For one month of the second period, the former carried two lambs per acre more than the latter, and for two and a half months of the second period carried 0.5 cattle more per acre than the latter.

Appearance of plots and composition of herbage.

At the commencement of the trial, there was more food on the wild white plot, and the stocking was arranged after a careful inspection of the growth on each plot. The grazing was kept under continual observation in order to prevent the wild white clover plot gaining an advantage over the other plot through being more heavily stocked in proportion to the growth of grass. Throughout the whole period of the experiment, the plot with no wild white clover in the seeding was more bare than the other plot, despite its lighter stocking, so that this plot was at no period handicapped through under-stocking. All visitors taken over the plots during the trial were of opinion that, although plot A carried more stock than plot B, there was always more grass on plot A. The appearance of the plots during the summer was very different, plot A having a high proportion of wild white in the herbage, while, in plot B, the herbage, though fairly satisfactory, as may be judged from Table II, was comparatively sparse, with daisies filling up the gaps. There were, however, small colonies of white clover to be observed in plot B, but the whole appearance was very different from the uniform take of this constituent in plot A. Table II gives the result of a botanical analysis by Dr. Alun Roberts made from samples taken on May 29, 1930.

TABLE II.

	Plot A.	*Plot B.*
	Per cent. by weight.	Per cent. by weight.
Grasses ...	64	79
Wild white clover ..	31	9
Red clover ...	—	trace
Yellow suckling clover ...	—	2
Miscellaneous ...	5	10
Total ...	100	100

It is seen from the above table that plot A contains more than three times as much wild white clover as plot B, but that, although none of this constituent was sown in the latter plot, indigenous wild white clover had gained a footing, so that in three years after the sowing of the seed it contributed to the extent of 9 per cent. of the herbage. The table also shows that plot A contains a smaller proportion of "Miscellaneous"—mostly weeds—than plot B, but also a smaller proportion of grasses.

May and June, as will be seen from Table III, were dry months, and by the end of June plot B was beginning to look rather bare. Even on plot A, where there was still a good bite, the possibility of a continuance of the drought was viewed with some misgivings. It was observed that the portions on plot B least affected by drought were those on which colonies of white clover had established themselves.

TABLE III.
Rainfall at Aber, April–October, 1930.

Month.		*Rainfall in inches.*
April	...	2.62
May	...	1.25
June	...	1.69
July	...	2.49
August	...	4.87
September	...	3.25
October	...	6.92

Health of stock, etc.

The health of the stock was good throughout the period, and no stock had to be removed on account of disease, etc. The lambs grazing both plots were ready for the butcher at the same time; thirty out of thirty-six of the first lot were sold on July 5 and there was no difference between the plots as regards the proportion of lambs ready for sale or the price obtained per lamb.

On July 20 it was observed that the ewes on plot A had a greater tendency to scour than those on B. Although no ewe was scouring badly, nearly every ewe on A scoured to some extent. No difference was noticeable in the lambs, there being only one or two of these showing traces of scouring. Three cattle on A also showed traces of scouring, but none was noticeable on those grazing plot B. During the second part of the summer no difference was observed between the two lots of lambs in this respect, but on September 26 five out of the six cattle

on A showed distinct marks of scouring, and only one on B. At the end of the trial, October 17, there was no difference between the two lots of cattle in this respect, nearly all cattle showing traces of scouring. It appears as if wild white clover had a slightly laxative effect on the ewes and yearling cattle.

TABLE IV.

Increase in live weight, 1930.

	Plot A.		*Plot B.*	
	Mean increase per head. lb.	*Total increase. lb.*	*Mean increase per head. lb.*	*Total increase. lb.*
PERIOD 1. (May 9–July 5).				
Lambs ...	34.6	691.5	32.2	514.5
Ewes ...	18.3	365.5	14.3	230.0
Heifers ...	73.0	292.0	68.0	272.0
Total: lambs, ewes and heifers ...	—	1349.0	—	1016.5
Total increase per acre ...	—	337.2	—	254.1
Ratio of production for period ...	—	133.0	—	100.0
PERIOD 2. (July 10–Oct. 17).				
Lambs ...	7.9	157.5	6.2	73.5
Heifers ...	175* & 84*	868.0	165.0	658.0
Total lambs and heifers. ...	—	1025.5	—	731.5
Total increase per acre ...	—	256.3	—	182.9
Ratio of production for period ...	—	140.0	—	100.0
PERIODS 1 AND 2 TOGETHER. (May 9–Oct. 17).				
Sheep ...	—	1214.5	—	818.0
Cattle ...	—	1160.0	—	930.0
Total increase sheep and cattle ...	—	2374.5	—	1748.0
Do. per acre	—	593.6	—	437.0
Ratio of production for period ...	—	136.0	—	100.0

* 175 is mean increase of four heifers comparable with those on Plot B. 84 is mean increase of two additional heifers put on plots.

Live weight increase from plots.

Table IV shows the live weight increase obtained on plots A and B, the increase per acre, the mean increase per head for each class of stock, and also the ratio of production obtained by putting at 100 the increase on plot B. The results are given

separately for both periods of the season, and also for the whole season. Table V gives the mean weights of the sheep and cattle at different times during the season. It will be observed from Table IV that the ratio of production is very similar in both periods of the season. If the production in the no wild white clover plot is put at 100 in both periods, the production on the

TABLE V.

Average weights in lb. per head of stock.

Date of weighing.	Plot A.				Plot B.		
	Lambs.	Ewes.	Heifers.	Heifers.	Lambs.	Ewes.	Heifers.
PERIOD 1.							
May 9	30.1	69.0	471.0	—	29.9	69.9	460.0
June 3	46.6	80.5	—	—	45.8	79.6	—
June 20	58.7	86.5	—	—	57.3	85.0	—
July 5	64.7	87.3	544.0	—	62.1	84.2	528.0
PERIOD 2.							
July 29	50.8	—	544.0†	693*	50.6	—	528.0†
Aug. 18	56.2	—	—	—	54.4	—	—
Aug. 28	58.2	—	—	—	56.8	—	—
Oct. 17	—	—	719.0	780	—	—	693

* Two additional heifers.
† Weight of heifers on July 5 and not on July 29.

wild white plot was 133 in the first and 140 in the second part of the season; taking both periods together, *i.e.*, the whole season, the proportion is 100 : 136. Thus, the inclusion of this constituent in the seeds mixture has resulted in increasing the productivity of the pasture in its third year by approximately

35 per cent., as measured by live weight increase. The greater increase in total meat production obtained on plot A was due to the additional stock carried rather than to greater increases per head of stock, there being little difference in this respect between the individual animals in the two plots. On plot A, however, the mean increase per head was slightly greater than on plot B in the case of each of the four classes of stock, and this suggests that the difference, though small, was not due to chance.

The live weight increase method of expressing the capacity of the pasture takes no account of the contribution of the pasture towards supplying the maintenance requirement of the stock. Thus, if one plot had done no more than maintain the stock in store condition and without growing for a certain period, its capacity would be put at zero for that period. It is possible that towards the end of a season a pasture might not produce much in excess of that amount, and a method of expressing the capacity in terms of " grazing days " is more satisfactory under such conditions. The comparison of pastures in terms of grazing days is more suitable if stock carrying capacity rather than meat producing capacity is to be compared. The comparison of plots A and B on this basis is shown below :—

Grazing afforded.	*A*	*B*	*A* : *B*
Cattle days ...	778	624	124 : 100
Sheep days ...	2880	2184	132 : 100

Thus, the proportion does not differ greatly from that obtained by a comparison of live weight production, though the superiority of the wild white clover plot is not quite so pronounced when the results are expressed in terms of grazing afforded. It is interesting to observe that, in both methods of comparison, the superiority of plot A is more pronounced in the second than in the first period. An examination of the plots led to the opinion that towards the end of the season the superiority of plot A became rather more marked as far as growth was concerned.

Capacity of the pasture.

In addition to demonstrating the value of wild white clover, these results are interesting in showing the high stock carrying and meat producing capacity of well managed temporary pasture. For eight weeks from May 9, plot A carried per acre five ewes, each with one lamb, and one yearling heifer; plot B carried one ewe and lamb less per acre. Even during August, September,

and the first half of October, plot A carried an average of 1.5 cattle per acre through the whole period, and five wether lambs (averaging 55 lb. live weight) for a month of the period. It is interesting to compare the live weight increases with some of the results of trials carried out at different centres in England.

Year.	*Centre.*	*Live weight increase per acre per annum.*	*Remarks.*
1930	College Farm, Aber. Plot (A)	593 lb.	Period only. May 9 - Oct. 17.
1930	Ditto. (Plot B.)	437 lb.	Ditto.
1897–1917	Cockle Park, Northumberland (3).	115 lb.	Poor clay. Permanent pasture slagged
1901–1910	Sevington, Hampshire (3).	157 lb.	Thin loam. Permanent pasture slagged.
1902–1920	Cockle Park (3).	192 lb.	As in Cockle Park above, but grazed by sheep and cattle.
1926	Thrussington (2).	260.7 lb.	Grazed by sheep only.

Perhaps a fairer comparison is that with good old pasture. One bullock per acre carried throughout the grazing season and fattened is regarded as an indication of good grass land. The usual increase is not more than about 300 lb. The field at the College Farm, Aber, on which the plots are situated is not a good one and had been grazed really bare by sheep during April.

These increases in live weight per acre are only given in order to indicate very roughly the high productivity at Aber. In addition to difference of rainfall, season, age of pasture, etc., the kind of stock exerts an important effect on live weight increase. For instance, stock nearing maturity and merely fattening would not show as large increases for a given quantity of grass as growing cattle and lambs. The kind of stock used in the trials quoted from other centres is not specified (2; 3).

It is interesting to observe that the substantial increase in production obtained by the inclusion of wild white clover in the seeds mixture was obtained although the control pasture, *i.e.*, the pasture which had received no seeding of white clover, was itself of a high order of productivity.

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MANURING PEDIGREE GRASSES FOR SEED PRODUCTION.

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Introduction.

As leafy strains of pedigree grasses bred at the Welsh Plant Breeding Station are now approaching the marketing stage it was considered essential that investigations should be undertaken to discover the most appropriate means of stimulating these strains to produce seeds through the agency of artificial manures.

Isolated areas of four leafy strains of pedigree perennial rye-grass, timothy, red fescue and meadow foxtail were laid down in drills two feet apart at the University College Farm, Nantcellan, in 1928. One island of pedigree cocksfoot had been laid down at this centre in 1927 and had produced a seed crop in 1928. The primary object of laying down these islands was to multiply initial stocks of mother seed as rapidly as possible, and it was therefore thought inadvisable to hazard the yield of seed from them by subjecting them to a series of manurial treatments, the effect of which could not be foreseen.

1929 Experiments.

The areas were dressed with a complete fertilizer consisting of 3 cwt. superphosphate (30 per cent.); 3 cwt. nitrochalk (12.3 per cent.) and 2½ cwt. potash (30 per cent.) per acre in the middle of March, 1929. The manured plots were duplicated, with unmanured plots for control.

The fertilizers stimulated the growth in a very short time although very little rain had fallen since their application, the increased growth on the cocksfoot plots being outstanding. The differences apparent between the manured and unmanured plots during the first few weeks became more pronounced as the season advanced. Vegetative growth was stronger on the manured plots from the commencement of spring growth, but towards harvest time a far more important phenomenon bearing directly on seed production was observed. This was the differential effect of the fertilizers on the production of fertile tillers in the various species. In this respect there was a sharp contrast between the red fescue and the cocksfoot. The former had developed a much smaller number of fertile tillers on the manured plots than on

TABLE I.

Showing (1) the pedigree strains treated; (2) the relative number of fertile tillers; (3) the average length of fertile tillers, and (4) the relative weights of vegetative growth. 1929 harvest.

Species.	*Strain number.*	*Type.*	*Relative no. of fertile tillers.*			*Average length fertile tillers cm.*		*Relative weights vegetative growth.*		
			Control.	*PKN.*	*Per cent. + or —*	*Control.*	*PKN.*	*Control.*	*PKN.*	*Per cent. Increase.*
Perennial rye-grass	S.23	Pasture... ...	100	141	+ 41	53.26	63.83	100	146	+ 46
Cocksfoot	S.26	Hay-pasture ...	100	199	+ 99	74.24	92.56	100	142	+ 42
Timothy	S.51	Hay	100	125	+ 25	83.00	87.64	100	184	- 84
Red fescue	S.59	Pasture... ...	100	41	—59	52.71	46.70	100	209	+ 109
Meadow foxtail	S.56	Hay-pasture ...	100	160	+ 60	72.56	65.98	100	141	+ 41

the unmanured, while the latter had increased the number of panicles to a very marked degree on the manured plots. The other three species reacted to the manuring in a similar manner as cocksfoot, but to a lesser extent.

The data in the table show that the fertilizers have reduced the number of fertile tillers in the red fescue to less than half, and nearly doubled that of cocksfoot. There are also substantial increases in the numbers of fertile shoots in the rye-grass, timothy and meadow foxtail.

The manures have produced increased length of stem in cocksfoot and rye-grass. The increase in these two species was very obvious in the field.

Vegetative growth appears to develop at the expense of panicle production, thus the red fescue has more than double the vegetative growth on the manured plots as compared with that on the unmanured plots, while it has increased by less than half on the manured plots of cocksfoot. Of the other species, timothy, while giving the least increase of fertile tillers on the manured plots, has developed correspondingly more foliage.

The only plots that showed a definite tendency to lodge were the manured plots of the perennial rye-grass.

TABLE II.

Showing (1) the pedigree strains treated; (2) the yield of seed; (3) the weight per 1,000 seeds, and (4) the percentage germination.

Species.	*Strain number.*	*Type.*	*Yield of seed. lb. per acre.*		*Weight per 1,000 seeds; grams.*		*Per cent. germination.*	
			Control.	*PKN.*	*Control*	*PKN.*	*Control.*	*PKN.*
Perennial rye-grass	S.23	Pasture	632	939	2.030	1.990	93	95
Cocksfoot	S.26	Hay-pasture ..	152	303	0.830	0.976	81	89
Timothy	S.51	Hay	434	659	0.328	0.427	95	94
Red fescue ..	S.59	Pasture	160	73	1.200	1.220	95	96
Meadow foxtail ..	S.56	Hay-pasture ..	39	67	1.088	1.029	85	87

It can be seen that the fertilizers have produced substantial increases in seed yields for all the species except the red fescue, which shows a very striking reduction on the manured plots. The red fescue result confirms the field observations and the yield is correlated with the tiller counts. This evidence is not in keeping with the recommendations of Nilsson (3), who urges the use of heavy artificial dressings including generous quantities of nitrogen for seed production of red fescue in Sweden.

The complete fertilizer has produced a proportionately greater increase of seed yield in the pedigree cocksfoot than in the other species, but it will be realized that the cocksfoot had

produced one crop of seed in the previous year, whereas the other species were in their first harvest year and followed a root crop. The soil after the latter would, therefore, be at a high pitch of fertility. It is again of interest to notice that the yield from the manured plot of cocksfoot corresponds with the tiller counts —that is to say, where the number of panicle-bearing tillers has been increased the yield of seed has also been increased.

Quality of seed.

The weight of individual seeds in timothy has been increased considerably by the manures, and this taken in conjunction with increased number of fertile tillers on the manured plots is reflected in the yield of seed per acre.

The rye-grass and meadow foxtail seem to have suffered slightly in the weight per thousand seeds from the manuring. This may be accounted for by the tendency to lodge in the former and the propensity of the latter to develop late inflorescences. This tendency of meadow foxtail appears to be accentuated to some extent by the fertilizers.

The effect of nitrogen alone on seed production.

In order to obtain a measure of the influence of nitrogen alone on seed production, duplicated plots were laid down at the same time as the above plots on a part of the cocksfoot area. The texture of the soil was, however, distinctly heavier on this portion. Nitrochalk (12.3 per cent.) at the rate of 3 cwt. per acre was applied in mid-March, and non-manured plots in duplicate were arranged as controls.

TABLE III.

Showing the effect of nitrogen on panicle production, length of panicles, vegetative growth, yield and quality of seed of a leafy strain of pedigree cocksfoot.

Plot.	*Relative number of panicles.*	*Av. length of panicles in cm.*	*Relative wt of vegetative growth.*	*Yield of seed, lb per acre.*	*Per cent germination*	*Weight per 1,000 seeds (gm).*
Control ..	100	82.4	100	236	77.8	0.925
Nitrogen ..	187	101.3	177	530	82.3	1.012

The data presented in Table III show the same trend as those for cocksfoot (Tables I and II) and indicate that nitrogen is the master factor in increasing the number of fertile tillers and the yield of seed. This evidence supports that of Stapledon and Beddows (5), who found that nitrogen stimulated the production of fertile tillers in cocksfoot. Nitrogen appears to improve the

power of germination and the weight of seed per thousand in this experiment. Ripening was delayed on the nitrogen plots by a few days only.

1930 Experiments.

The results obtained from the 1929 experiments were regarded as sufficiently indicative to warrant further investigations in order to ascertain the special manurial requirements of various pedigree strains for seed production.

A more comprehensive scheme was formulated in 1930 to include differential manuring with nitrogen, phosphates *cum* potash and a complete fertilizer. The plots were replicated from two to six times, according to the size of the areas available, on multiplication islands.

The plots at the Nantcellan centre were laid down on crops in their second harvest year and at Buttington on first harvest year crops. All the species at the latter centre followed sugar beet, except the pasture-hay strain of timothy which followed a seed crop of red clover. The red fescue at Buttington was the only crop sown broadcast, the others being sown in drills two feet apart. Manurial dressings were applied at the beginning of April as follows : *Plot A*, control; *Plot B*, 2 cwt. nitrochalk (15.5 per cent.); *Plot C*, 5 cwt. nitrochalk (15.5 per cent.); *Plot D*, 3 cwt. superphosphate (30 per cent.) plus 3 cwt. potash (30 per cent.); *Plot E*, 2 cwt. nitrochalk (15.5 per cent.) plus 3 cwt. superphosphate (30 per cent.) plus 3 cwt. potash (30 per cent.).

Tiller production.

The data submitted in Table IV agree with the results obtained in 1929 (Table I) which showed that the complete fertilizer reduced the number of fertile tillers in red fescue and increased it considerably in the other two species. The relatively greater increases of barren tillers in the red fescue also corresponds with the previous result obtained on the PKN plots.

A decrease in the number of both fertile and barren tillers follows the application of phosphates plus potash in perennial rye-grass and red fescue while timothy shows an increase of barren tillers.

Superphosphate, according to Stapledon and Beddows (5), reduces the fertile and the barren tillers of cocksfoot and from the above table it appears to exercise a similar influence on the red fescue, the only species to which it was applied by itself. When potash is added to the phosphate, the mixture has not increased the fertile tillers of that grass, but has depressed the number of barren tillers still more.

TABLE IV.

Showing the influence of the various manurial treatments per acre on the production of (a) fertile tillers and (b) barren tillers of pedigree strains of rye-grass, timothy and red fescue at the Nantcellan centre, Gât Gôch.

Species.	*Strain number.*	*Relative number of fertile tillers with control at* 100.					*Relative number of barren tillers with control at* 100.				
		Control.	*Nitro-chalk 2 cwt.*	*Nitro-chalk 5 cwt.*	*Super* 3 *cwt.* + 30% *potash* 3 *cwt.*	*Super* 3 *cwt.* + 30% *potash* 3 *cwt. and nitro-chalk* 2 *cwt.*	*Control.*	*Nitro-chalk 2 cwt.*	*Nitro-chalk 5 cwt.*	*Super* 3 *cwt.* + 30% *potash* 3 *cwt.*	*Super* 3 *cwt.* + 30% *potash* 3 *cwt. and nitro-chalk* 2 *cwt.*
Perennial rye-grass ...	S.23	100	197	226	97	187	100	121	146	80	136
Timothy	S.51	100	160	145	101	135	100	99	85	118	110
Red fescue ...	S.59	100	103	98*	97	89	100	183	71*	60	161

* Superphosphate only—3 cwt. per acre.

The dressings of nitrogen have increased the number of fertile tillers of the rye-grass and timothy very considerably, and have also increased the number of barren tillers of the rye-grass and the fescue.

The large increase in the number of fertile tillers in this second seed crop of the rye-grass is comparable with the increase of panicles in the second seed crop of cocksfoot (Table III). The heavier dressing of nitrogen has surpassed the lighter dressing on the rye-grass in the production of fertile tillers, and furthermore, the crop did not become laid. It is important to realize that although more than three times the quantity of nitrogen applied to the first seed crop was applied to the second seed crop, yet the former crop had a definite tendency to lodge. It is true that the second crop of seed was smaller, but on the other hand 1930 was a much wetter season than 1929.

Severe lodging occurred on the nitrogen plots of meadow fescue and also on the broadcast plots of red fescue. The extreme pasture type of timothy and to a lesser extent the pasture strain of cocksfoot reacted to the heavier dressing of nitrogen in a similar manner. These four strains were, however, grown on a particularly fertile field which had carried sugar beet previously.

Yield of seed.

A study of Table V shows that nitrogen has a very pronounced effect on the seed yields of all the strains, except the fescues. Even the lighter dressing of nitrochalk has depressed the yields of the latter, except the red fescue sown broadcast. The increase in the first crop of the broadcast red fescue is of doubtful advantage since the crop was badly lodged and this, together with an increased bottom growth, made cutting and harvesting more difficult.

It will be noticed further, that the heavier dressing of nitrogen in comparison with the lighter dressing has reduced the yields of all the first year crops. On the other hand, the second year crops, except the red fescue, have increased in proportion to the quantity of nitrogen applied. The implication is that the demand for nitrogen increases with the reduction of soil fertility. The yields of the rye-grass and timothy (Table V) are low in comparison with the yields from the first year crops (Table II), due partly to the severe grazing in mid-winter and the removal of a seed crop. In addition to this, the abnormally heavy rainfall undoubtedly caused considerable leaching of soil nutrients, and in the summer did not conduce to abundant seed setting and seed filling. On the other

TABLE V.

Showing the effect of manurial treatments on the yield of seed of leafy strains of pedigree grasses.

Species.	*Strain Number.*	*Centre.*	*Type.*	*Harvest year.*	*Treatments with yields in lb. per acre.*				
					Control.	*Nitro-chalk 2 cwt. per acre.*	*Nitro-chalk 5 cwt. per acre.*	*Super 3 cwt. + 30% potash 3 cwt. per acre.*	*Super 3 cwt. + 30% potash 3 cwt. + nitro-chalk 2 cwt. per acre.*
Perennial rye-grass	S.23	Gât Goch, Nantcellan ...	Pasture	2nd.	129.6	205.7	281.3	120.5	261.9
Meadow foxtail ...	S.56	,, ...	Hay-pasture ...	,,	106.5	136.9	193.4	115.5	160.0
Timothy	S.51	,, ...	Hay	,,	205.5	277.0	292.6	214.5	249.0
Timothy	S.48	Welshpool, Montgomery	Pasture-hay ...	1st.	397.1	499.7	497.0	405.0	531.3
Timothy	S.50	,,	Extreme pasture	,,	531.3	520.7	494.4	483.9	552.3
Cocksfoot	S.29	,,	Pasture	,,	393.6	487.7	417.5	403.0	455.5
Meadow fescue ...	S.53	,,	Hay	,,	392.4	364.5	294.3	375.3	315.0
Red fescue (1)* ...	S.59	,,	Pasture	,,	524.5	544.0	467.0	439.5	537.0
Red fescue (2) ...	S.59	Gât Goch, Nantcellan ...	Pasture	2nd.	166.6	152.6	150.2†	141.9	140.3
Average of species other than fescues					293.9	354.6	362.7	290.4	368.3
Average of fescues, excluding red fescues (2) ...					458.4	454.2	380.6	407.4	426 0

* Broadcast. † Superphosphate only—3 cwt. per acre.

hand, the yields from the meadow foxtail have exceeded those of the first year by a wide margin, the grazing not having been quite so severe and the grass having the advantage of earlier growth together with an earlier harvest.

Under the conditions of these experiments in 1930, it would appear that on fertile soils the equivalent of 2 cwt. per acre of nitrochalk is an economic dressing for first year crops grown in drills. Beyond this quantity it is of doubtful advantage and even this dressing appears to be distinctly harmful to the fescues and the extreme pasture strain of timothy on land in good heart.

The mixture of phosphates and potash apparently exercises little beneficial influence on the yields of seed, in fact the figures in Table V show that it has reduced the yield of seed in all the fescues. This is in agreement with the counts of fertile tillers. Superphosphate by itself has reduced the yield of seed on the fescue plots at Nantcellan and a further reduction has taken place following the addition of potash.

The mineral manures when added to the lighter dressing of nitrogen have adversely affected the seed yields of the fescues; without exception the yields from the complete manures are lower than those from the plots dressed with 2 cwt. of nitrochalk, and even the yields from the latter are lower than those from the control plots excepting the broadcast plots of red fescue. This evidence agrees with the results obtained in 1929 (Table II) and indicates that the low production of fertile tillers and the seed yields of the fescue on the plots dressed with the complete fertilizer can be attributed to the adverse effect both of the mineral manures and of the nitrogen. In this connection it is of interest to note that according to Witte (6), and to Danish reports (1) meadow fescue is commonly grown for seed in Sweden and Denmark on peaty soils. Peaty soils are generally considered to be deficient in minerals and available nitrogen, but Welsh hill soils to which fine-leaved fescue is propense are also low in phosphate and available nitrogen content.

Hansen (2) states that the yield of meadow fescue seeds in Denmark increases proportionately with the quantities of nitrogen applied up to the equivalent of 3 cwt. of sulphate of ammonia per acre. On the other hand, Rinne (4) states that nitrogen decreases the yield of meadow fescue seed on moorland.

The phosphates and potash when added to the nitrogen dressing have raised the yields of the rye-grass, foxtail and two strains of timothy above the yields from the smaller dressing of nitrogen. The increases are more appreciable in the first two of these grasses which were in their second harvest year, but

the yields in the three species are heavier following the dressing with 5 cwt. nitrochalk than with the complete fertilizer.

A marked decrease is observed with the addition of minerals to nitrogen in the hay strain of timothy, and this again corresponds with the decrease in the number of fertile tillers (Table IV) as compared with the numbers from the nitrogen-only plots. It is remarkable that in each pair of corresponding plots (replicated six times) of minerals *cum* nitrogen and nitrogen alone, the latter produced the highest yield of seed.

Phosphates with potash had in no case been able to counteract the lodging effect of nitrogen where that feature was at all serious, and there was no discernible difference in maturity between the plots dressed with the complete fertilizer and the nitrogen-only plots.

Quality of seed.

On reference to Table VI it is seen that the manurial treatments have had no appreciable influence on the power of germination. There appears to be a slight difference in favour of the control and phosphate plus potash plots.

Although some of the crops were badly lodged as a result of the application of nitrogen, the germination of the seeds from such crops has not suffered very greatly. The meadow foxtail is rather exceptional in that here we have a reduced germination on each plot receiving a dressing of nitrogen, and in all probability this is due to a higher proportion of immature seed from late spikes.

There does not seem to be any advantage in adding minerals to the nitrogen dressing for the express purpose of increasing the viability of the seeds.

The weight per 1,000 seeds of the rye-grass has been improved by all the manurial treatments, especially by the heavier dressing of nitrogen and the mineral manures. When the latter are added to nitrogen the effect of both is cumulative, and this increase of seed weight can be correlated with increases in total weights (Table V) and tiller counts (Table IV).

The double effect of increasing the tiller counts by means of nitrogen and the seed weights by means of the minerals has helped to produce a substantially increased seed yield in the second harvest year of the rye-grass.

The manuring has increased the average weights of the red fescue seeds, but this improvement bears little relation to the total yields per acre.

The fertilizers have had the opposite effect on the seed weights of timothy (S.51), reducing them in every instance, and

TABLE VI.

Showing the effect of manurial treatments on the germination and weight per thousand seeds of leafy strains of pedigree grasses.

Species.	*Strain number.*	*Centre.*	*Type.*	*Control.*		*Nitrochalk 2 cwt. per acre.*		*Nitrochalk 5 cwt. per acre.*		*Super 3 cwt. + 30% potash 3 cwt. per acre.*		*Super 3 cwt + 30% potash 3 cwt. + nitrochalk 3 cwt. per acre.*	
				Per cent. Germination.	*Weight per 1,000 seeds (gm)*	*Per cent. Germination.*	*Weight per 1,000 seeds (gm)*	*Per cent. Germination.*	*Weight per 1,000 seeds (gm)*	*Per cent. Germination.*	*Weight per 1,000 seeds (gm)*	*Per cent. Germination.*	*Weight per 1,000 seeds (gm)*
Perennial rye-grass	S.23	Gât Gôch, Nantcellan ..	Pasture	67	1.372	72	1.388	76	1.532	71	1.436	76	1.538
Meadow foxtail ..	S.56	,, ..	Hay-pasture ..	65	0.651	56	0.635	48	0.628	66	0.639	56	0.590
Timothy	S.51	,, ..	Hay	89	0.308	91	0.256	83	0.252	85	0.264	84	0 272
Timothy	S.48	Welshpool, Montgomery	Pasture-hay ..	96	0.292	95	0.292	97	0.284	97	0.280	95	0.286
Timothy	S.50	,, ..	Extreme pasture	96	0.254	95	0.252	92	0.256	96	0.260	94	0.258
Cocksfoot	S.29	,, ..	Pasture	97	1.071	95	1.063	96	1.090	98	1.099	94	0.973
Meadow fescue ..	S.53	,, ..	Hay	97	2.070	97	2.052	93	2.040	96	2.136	94	2.05
Red fescue (1) ..	S.59	,, ..	Pasture	93	0.927	92	0.902	88	0.932	94	0.900	92	0.844
Red fescue (2) ..	S.59	Gât Gôch Nantcellan ..	Pasture	90	0.898	92	0.912	98*	0.960*	92	0.985	93	0 923
Averages, excluding red fescue (2) ..				87.5	0.868	86.6	0.855	84.1	0.877	87.9	0.877	85.6	0.85-

* Superphosphate only—3 cwt. per acre.

this result is the reverse of that obtained with the first year crops of this strain (Table II).

The seed weights of meadow foxtail have varied in a similar manner to those of timothy (S.51).

There appear to be no significant differences between the seed weights from the variously treated plots of the first seed crops of the other pedigree strains.

Time for applying nitrogen.

In order to test the effect of the time of applying nitrogen on the yield of seed, replicated plots were laid down in the spring of 1930 on a pedigree strain of cocksfoot (S.26). This leafy strain was grazed rather severely during the previous winter, and as two seed crops had been produced from it, the soil was not in particularly good heart.

The nitrogen was applied in the form of nitrochalk (15.5 per cent.) at the rate of 4 cwt. per acre at monthly intervals from the beginning of April to the beginning of June. The crop was in full panicle before the last application.

TABLE VII.

Showing the dates at which the manures were applied, together with the yield and quality of the seed of a leafy strain of pedigree cocksfoot.

Treatment.	*Date of application*	*Yield in lb per acre*	*Increase over control lb. per acre*	*Germination*	*Weight per 1,000 seeds (gm*	*Remark .*
Control	—	171.7	—	85	0.962	
Nitrochalk, 4 cwt. ..	11/4/30	226.8	55.1	87	0.965	Growth about 4" to 6" high.
" ..	9/5/30	195.9	24.2	86	0.950	Growth about 12" to 15" high
" ..	6/6/30	186.1	14.4	87	1.010	Growth about 24" to 30" high

The data presented in Table VII show that the greatest increase in the yield of seed was obtained from the earliest dressing and that the increments over the control plots decreased in proportion to the interval of time elapsing between the dressings. Thus the April dressing gave twice the increment of the May dressing and four times the increment following the June dressing.

From the results of the previous year (Table III) we know that an early dressing of nitrogen stimulates the production of fertile tillers to a very marked degree in cocksfoot, and that the yield of seed is closely correlated with the number of fertile tillers. It appears then from this experiment that a late dressing

is incapable of producing a very material increase of seed yield, probably on account of the failure of such a dressing to induce the production of increased numbers of panicles.

In cereals an early spring dressing of nitrogen promotes barren tillering, but not so much the yield of grain, whereas late dressing increases the grain yield, but not the number of tillers.

Hansen (2) mentions that Danish experiments proved April dressings of nitrogen to be superior for seed production to earlier dressings, but the applications were not continued beyond the first week in April.

The time of application of the manure has not influenced the germination, but the last application appears to increase the seed weights.

Summary.

(1) These preliminary investigations have proved artificial manures to be exceedingly potent in stimulating leafy strains of pedigree grasses to produce abundant seed.

(2) The evidence reveals very significant differences as between species and species in their response to fertilizers. Under the conditions of these experiments artificial manures reduced the seed yields of pedigree red fescue in the first and second year crops and the first seed crop of meadow fescue. On the other hand, the fertilizers stimulated the seed-producing potentialities of the strains of cocksfoot, rye-grass and timothy.

(3) Nitrogen has proved much the most potent element for inducing these leafy strains to produce seed. It has been shown further that there is a limit beyond which larger quantities of nitrogen either have little effect or even become harmful. It would appear that the higher the natural fertility of the soil and the more propense the strain of grass is to become lodged, the less need is there to utilize artificial nitrogen. Second year and subsequent crops on the contrary demand heavier dressings of nitrogen, particularly after a wet, open winter and when the grasses have been subjected to winter grazing.

(4) Phosphates and potash when applied together, or when both are added to nitrogen, depress the yield of the fescue seed; on the whole, their effect on the yields of the other species has been negligible. These manures have, however, improved the yields of the second year crops of the rye-grass and foxtail, while reducing the yield of the second crop of timothy (S.51).

(5) The fertilizers have, on the whole, not influenced the power of germination to an appreciable extent. In the dry year of 1929 they tended to improve germination but in the wet year

of 1930 the nitrogenous manures had a tendency to reduce the germination where the crops lodged or produced late fertile shoots.

(6) The seed weights are, on the whole, increased by manuring, but species vary in this respect from year to year, and the response to manures varies from species to species.

(7) Phosphates and potash tend to reduce both fertile and barren tillers, while nitrogen induces a large increase in the number of fertile shoots of the rye-grass, cocksfoot, timothy and meadow foxtail; in red fescue the number of fertile shoots was reduced by nitrogen.

(8) Early applications of nitrogen produce better results than late applications for seed production.

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SEED PRODUCTION OF PEDIGREE GRASSES IN MONTGOMERYSHIRE.

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Welsh farmers of a century or so ago realized that seed saved from indigenous grasses and clovers was superior to imported seed. Herbage plants such as rye-grass, white clover and red clover derived from seed harvested from old pastures proved to be more suited to local conditions than those derived from the seed offered ordinarily on the market.

The frequent failures of red clover crops grown from commercial seed, due to clover sickness and probably winter killing, caused serious attempts to be made to produce seed from local strains. Some of the most energetic of the County Agricultural

Societies (1) were so convinced of the importance of such efforts that they encouraged the practice of saving indigenous seed by offering substantial awards annually for the best crops of clover and grasses kept for seed. Interest was stimulated further by the offer of awards for the most efficient methods of cleaning the seeds, and several ingenious machines were devised.

The practice of saving local seed was held in such high esteem that it was regarded as the " hall-mark " of a good farmer, but unfortunately few farmers can claim this distinction at present. Undoubtedly some excellent strains of red clover were lost when they were no longer harvested for seed.

There are, however, two districts in Wales which have cultivated distinct types of red clover for seed for several generations. A very persistent type of clover known as the Montgomery late-flowering red clover has been extensively grown in the Welshpool district of Montgomeryshire for at least a hundred years, and the growers have now formed an association for the purpose of registering and inspecting the crops. A modern plant has been set up for cleaning and grading the seed, which is sold in sealed bags from the depot of the Association.

An intermediate type of red clover is native to the Vale of Clwyd in North Wales, and takes its name from that district where it has been extensively grown for many years.

Seed from pedigree strains.

Certain strains of pedigree grasses bred at the Welsh Plant Breeding Station were harvested for seed on a field scale in Montgomeryshire during 1930 (Table I). This district was chosen on account of its comparatively low rainfall, and because it is within reasonable distance of the Station.

All the strains considered here, except red fescue which was broadcast, were sown in drills 2 ft. apart on a rolled surface. A Planet Junior drill covered the seeds satisfactorily and one further rolling produced a firm seed bed. The seeding was advisedly heavy to secure a regular establishment and to keep weeds down from the outset.

Care was taken to have the areas as well isolated as possible from similar species to avoid wind pollination by inferior types. It will be observed that two strains of timothy were grown on one farm, but they were over half a mile from each other. In all probability there is little danger of crossing between the hay types of timothy and the extreme pasture types, and if convenient they should be grown for seed on the same field. The extreme pasture types flower so much later than the hay types that this in itself inhibits cross-fertilization.

Cultivation in the seeding year.

There is need to emphasise the importance of a clean seed bed, and the killing of germinated annual weed seeds before the grass seeds are drilled. This reduces the need for hand-weeding to a minimum and enables the grasses to make headway from

TABLE I.

Showing the pedigree strains, centres, rate and date of seeding, and acreage of the areas harvested for seed in Montgomeryshire during 1930.

Species.	*Type.*	*Strain. number.*	*Centre.*	*Rate of seeding lb. per acre: real value = 100.*	*Date of seeding.*	*Area in acres.*
Cocksfoot	Hay-pasture	S.26	White Hopton, Sarn ...	5	17/4/29	$3\frac{3}{4}$
,,	Pasture	S.29	Buttington Hall, Welshpool	5	15/4/29	$1\frac{1}{4}$
Timothy	Hay	S.51	White Hopton ...	4	18/4/29	$\frac{1}{4}$
,,	Pasture-hay	S.48	Buttington Hall ...	4	16/4/29	$2\frac{1}{2}$
,,	Extreme pasture	S.50	,, ...	4	15/4/29	$\frac{1}{4}$
Meadow fescue	Hay	S.53	,, ...	7	15/4/29	$\frac{1}{4}$
Red fescue	Creeping	S.59	,, ...	16*	15/4/29	1

* Red fescue was sown broadcast under spring oats.

the beginning. If the land is suspected of being very foul with annual weed seeds it is an advantage to delay the seeding until May, by which time the soil should have been thoroughly stirred to stimulate the germination and killing of the weed seeds. There

is the risk of drought setting in and injuring the grass seedlings if the sowing is delayed until late in May. A difficulty of this kind can be met by rolling the drills heavily and repeating the rolling if the soil is still loose.

Generally land of a heavy texture and light soils are not regarded as ideal for the production of grass seeds, owing to the difficulty of securing good tilth and of subsequent inter-drill cultivation in the former and the risk of a light crop through drought in the latter. Stiff soils can produce satisfactory crops under skilled management and appropriate implements, including a rototiller; lightish soils can be made productive by the addition of organic manure supported by generous dressings of nitrogen.

The drills should be scuffled as soon as the seedlings form discernible lines, but great care must be exercised to avoid disturbing the young plants by scuffling too closely and covering them with soil. Most scufflers are adjustable and should be worked at a narrow gauge at first; as the grasses grow stronger they can bear closer cultivation. The ideal implement for this work is undoubtedly the rototiller, as not only is it more manageable than a scuffler, but it pulverises the soil extraordinarily well, and the more thorough the working of the soil the greater is the yield of seed.

A small quantity of mustard seed, a pound or so to the acre, mixed with the grass seed has been found to be advantageous for indicating the drills so that scuffling may be undertaken in a comparatively short time. The mustard has fulfilled its purpose once it has enabled the drills to be cleaned, and should be cut down immediately afterwards.

When no indicator plant has been used and where the annual weeds have grown so profusely as to obliterate the lines of grass seedlings, the farmer should not decide to plough up the whole area; rather should he take the mowing machine over and clear the weeds. In a short time the drills are discernible and can be cleaned with safety. Even though a bad start may be made, energetic measures undertaken afterwards will ensure a satisfactory crop in the following year. A dry summer coupled with the " blanket " effect of weeds may cause a considerable amount of delayed germination of small grass seeds, such as those of pasture types of timothy; by the end of summer, provided weeds have been kept in check, the " dormant " seeds germinate and form regular drills.

The drills should be scuffled three times in the seeding year to keep the land clean and encourage a vigorous vegetative growth. A strong autumn growth appears to be a condition of

a good seed yield in the following year for some of the most leafy types, cocksfoot being outstanding in this respect. A dressing of nitrogen in the early autumn is strongly recommended when growth is very backward during the summer, and, on the other hand, even if the growth is very forward in the autumn, it is advisable to avoid grazing the drills. None of the strains under review here were grazed before the crops of seed were harvested, but those species such as the larger fescues which are prone to lodging on land of high fertility could probably stand light grazing in the autumn or not later than the end of March of the first harvest year.

Spring management.

Ordinarily two spring scufflings are quite sufficient if proper management has been attended to in the seeding year, and it is an advantage to complete the cultivation before the spring growth spreads across the inter-drill spaces. Roguing of perennial weeds and grasses not true to type is most conveniently done at this time to avoid trampling, which would be inevitable if the work were delayed until harvest time. One obvious advantage of the drill method over the broadcast is that it ensures a cleaner sample of seeds and reduces the loss of good seed in the process of cleaning to a minimum when cleaning has been thoroughly done in the seeding year; leafy strains of grasses form admirable smothering crops in succeeding years.

A spring application of nitrogenous manures undoubtedly pays even on land which carried roots previously; the optimum dressing varies, however, according to the species and strain of grass and also with the degree of fertility of the soil. Two cwt. per acre of a 15 per cent. nitrogenous manure can be applied with safety to cocksfoot and timothy strains on highly fertile soils, and up to three cwt. or even more on less fertile soils in the spring of the first harvest year. The fescues on the other hand are adversely affected by nitrogen in regard to seed production.

Harvesting.

If the seed production of pedigree grasses is considered from the point of view of the farmer who seriously contemplates taking up this practice in terms of several acres, it is important to realize that the average dates for harvesting these grasses suit his convenience remarkably well. The majority of strains are ripe for cutting between the hay and the corn harvests, and timothy matures shortly after the corn crops are put in the stook.

The determination of the optimum time for harvesting each strain requires some judgment, for there is a tendency in grasses

for some precocious heads to be overripe before the bulk is sufficiently mature to warrant cutting. It is therefore advisable with most strains to permit a certain amount of shedding to occur before harvesting the crops and to allow the stems below the heads to turn colour. Meadow fescue may be more ripe than it appears, and if the seeds shed easily when a few panicles are drawn through the hand the crop is sufficiently matured.

The ordinary corn binder deals with the grasses satisfactorily, provided the crops are managed in such a manner that no lodging occurs. The binder is adjusted so that the narrowest sheaves possible are produced, for grass stems not only pack closer than corn but in these pedigree strains there is always a fair quantity of greenish leaves as well at harvesting. The time required for conditioning in the field is shortened further by raising the knife bar so that a leafy stubble of about nine inches is left behind. The taller strains when cultivated in drills develop stems at least as long as an average corn crop and often several inches longer, so that the binder is capable of turning out neat sheaves even when a length of stem is neglected.

A considerable saving of seed can be effected by attaching seed collecting boxes to the binder. Several standard binders have such boxes specially designed for the purpose of collecting the seed threshed out in the process of binding. There are other boxes on the market adapted for any make of machine and commonly used for collecting weed seeds in harvesting ordinary corn crops. These can be purchased at small cost and the advantage gained from them in one year more than covers the outlay. The sheaves of the grass crops stooked in fours and tied with binder twine to withstand gales require about a fortnight to condition on the field when the weather is reasonably good, preferably more if they contain a fairly large amount of foliage and the weather is unfavourable.

Threshing and cleaning.

The crops are put through the thrasher immediately they are carted, for unless they are thoroughly dry when brought in there is grave risk of heating in the stack and of serious injury to the seed. The Station owns a specially constructed peripatetic thrasher worked by a 5 h.p. engine attached to it for threshing the pedigree crops in the Welsh counties. The seeds are brought back to the Station in a lorry directly they are threshed and spread out in a well ventilated seed house where they are turned frequently until they are in a condition to sack with safety.

A "seed tapper" cleaning machine turns out high-class samples of seeds. The essential features of this machine are a

TABLE II.

Showing the yield and quality of seed of the various pedigree strains.

Species.	*Type.*	*Strain number.*	*Yield in lb. per acre.*			*Percent. purity.*		*Percent. germination.*		*Percent. heavy seed to light heavy seed.*		*Weight per 1000 seeds in grams.*	
			1sts.	*2nds.*	*Total.*	*1sts.*	*2nds.*	*1sts.*	*2nds.*	*1sts.*	*2nds.*	*1sts.*	*2nds.*
Cocksfoot	Hay-pasture	S.26	609	31	640	93.1	72.8	95.8	88	93.7	87.2	0.933	0.580
,,	Pasture	S.29	368	54	422	90.8	93.8	96.8	98	91.3	95.9	1.057	0.969
Timothy	Hay	S.51	456	—	456	91.1	—	85.0	—	99.6	—	0.370	—
,,	Pasture-hay	S.48	460	—	460	95.0	—	95.0	—	100.0	—	0.292	—
,,	Extreme pasture	S.50	464	—	464	95.0	—	95.0	—	99.9	—	0.252	—
Meadow fescue	Hay	S.53	374	58	432	95.2	93.9	92.0	96	95.9	96.7	2.136	2.062
Red fescue	Creeping	S.59	445	36	481	93.0	48.0	94.0	94	94.1	95.9	0.922	0.728

series of sieves which grade the seeds according to width and a pair of indented cylinders which grade according to seed length.

The seeds of the pasture types of timothy, owing to the tenacity with which they are held in the glumes, have to be put through a husker before they are passed through the seed tapper.

Yield.

In Table II the "firsts" represent the larger and best quality seeds, and the "seconds" the smaller seeds together with a higher proportion of inert matter and weed seeds, if any.

The total yield of 640 lb. per acre from the hay and pasture cocksfoot (S.29) has exceeded the most sanguine expectations, and when compared with the average yield of ordinary cocksfoot in Denmark which only amounts to 428 lb. per acre (2) and about 8 cwt. in the East of England (4) the capacity of strains bred primarily for their leafiness to produce abundant seed under skilled management will be realised. The yield is nearly double that usually expected from stemmy types of cocksfoot in the eastern counties and more than 50 per cent. higher than that expected in Denmark.

The other species and strains referred to in the table have all given a total yield of over 400 lb. to the acre. These yields, however, for various reasons fall far short of the maximum yields possible for these strains. Firstly, all the seed areas were dressed in spring with three cwt. per acre of nitro-chalk (15.5 per cent.) and for fertile soil which previously carried roots this quantity appeared to be excessive. Under these conditions the meadow fescue lodged very badly before ripening and there was a similar tendency in the pasture cocksfoot. The effect of manurial treatment on grass seed production is dealt with in the current volume of this Journal (page 195). About one-third of the red fescue received the same dressing, which caused it to lodge very badly, and the extreme pasture type of timothy also suffered in this respect. On the other hand the intermediate cocksfoot (S.26) and the taller strains of timothy (S. 48 and S. 51) responded to nitrogenous manuring without lodging.

Strong gales reduced the yield of meadow fescue by about one-half at the time when it was just ready for harvesting, and yet the seed saved compares favourably with the Danish average of 446 lb. per acre (2) and the Swedish average of 462 lb. per acre (6). The pasture cocksfoot would show better weights if a storm had not intervened at harvest time. Of the two taller strains of timothy S. 51 was on rather indifferent soil and made

poor headway in the seeding year; S. 48, although it made a good recovery in the spring of 1930, would have undoubtedly produced a better crop if the growth had been strong and continuous from the beginning.

The weather conditions during 1930 must also be considered in relation to yields of seed. The abnormal number of wet days probably affected pollen distribution to a considerable extent, and the inclement weather at the end of August was not conducive to the filling of the timothy seeds. It was difficult to thrash out the timothy heads as cleanly as one would have liked on this account.

Quality of seed.

The data presented in Table II leave no doubt as to the quality of seed that can be produced from these pedigree grasses even under very indifferent weather conditions. There was hardly a day without some rain after they were put in the stook and yet they show remarkably high germinating power. The percentage germination of timothy S. 51 would probably have been higher if the crop had been left in the stook a few days longer, and if the weather had not been so excessively wet at threshing time.

The purity of the seeds can be regarded as very satisfactory when it is realised that the small quantities of impurities in the " firsts " are almost wholly composed of inert matter, chiefly portions of leaves and stems. One interesting fact emerges from a study of the purity figures for the second grade of seeds, and that is the superiority of the drill system over the broadcast. The red fescue was cultivated broadcast under oats and produced a sample of seeds containing a much higher proportion of impurities than the species grown in drills. These impurities included a much higher proportion of weed seeds and other grasses than was the case with the larger grasses which were grown in drills. There is evidence from experiments now in progress that the same applies to the latter when sown broadcast.

The percentage of light " seed " or seeds devoid of caryopses depends very largely on skill in adjusting the cleaning machinery so that the amount passing over with the sound seed is reduced to a minimum and at the same time on taking sufficient care to avoid blowing good seed away. The separation of light seeds in the timothy strains is a simple matter.

The weight per 1,000 seeds of cocksfoot, S. 26, appears from the data in the table to be lower than that of S. 29. This is not usually the case and can be accounted for here by reference to the higher proportion of seeds that have passed to the second

grade in S. 29. The purity and germination of the second grade of the latter would justify their addition to the first grade for ordinary purposes.

Timothy strains present a definite variation in regard to their seed weights; the hay type produces the largest seed and the pasture type the smallest. In a favourable year, however, the seed weights of these strains are much greater: for example, the weight per 1,000 seeds of the hay type S. 51 harvested at Aberystwyth in 1929 was 0.427 grams, rather more than that of ordinary samples of commercial timothy (0.410 grams).

The seed weights of the fescues are about the average for commercial samples.

By-products.

A well managed field growing these grasses in drills presents a very handsome appearance at harvest time. The crop compares favourably with oats in length and the growth is so vigorous in the larger strains that the drills as such are hardly discernible. This means that a heavy yield of straw is available for the grower after the crop has been threshed, and having regard to the proportion of leaf in such material, its feeding value should compare favourably with that of cereal straw. Stapledon (5) mentions that the straw of rye-grass threshed for seed in New Zealand is sold for about £4 per ton for fodder. It may be of interest to mention that the straw of the taller strains was in one instance used successfully for thatching.

Management of the seed production area after harvest.

When the practice of seed production is taken up seriously two things with regard to after-harvest management merit due consideration on the part of the grower. Firstly, the seed area is managed in such a way that the maximum yields are obtained over a number of years, and secondly, efforts are made to prevent the establishment of weeds. Witte (6) states that the yield of cocksfoot seed grown in drills increases in successive crops and is usually highest in the fourth crop. To this end the drills are thoroughly scuffled after the crop is harvested and before the aftermath has developed to interfere with its working. The scuffling not only checks the inroads of weeds but also aerates the soil, and thus helps to maintain the vigour of the drills. When vigorous growth is stimulated in this way the crops become practically self-cleaning in the case of the most leafy strains.

Some of the high fertility demanding strains such as perennial rye-grass after having carried one or two crops of seed may require, in the autumn, a light dressing of well rotted farmyard

manure free from weed seeds, supported, in the spring, by a dressing of nitrogenous mature, unless growth is sufficiently forward. Most other strains produce two or three crops with the aid of nitrogen on reasonably fertile soils.

Many of the pedigree strains when grown in drills produce an abundance of winter green foliage which is in sharp contrast to that of neighbouring leys during the winter months. Growers are often tempted to graze them down with the idea of doing them good and especially if winter keep is short. In practice, however, it has been found on the Continent (8) and evidence at the Station points in the same direction, that a better seed crop is obtained by not allowing the animals to graze at any period of the year, unless this is done with a view to preventing the lodging of rye-grass or fescue.

Conclusions.

(1) Evidence is produced to prove that pedigree leafy strains of cocksfoot, timothy, meadow fescue and red fescue have been stimulated to yield abundant seed.

(2) These yields compare very favourably with the average yields of stemmy types grown for seed in this country and abroad.

(3) Grass seeds of high germinating power and purity can be produced under Welsh conditions even in an abnormally wet year.

(4) The drill method without cover crops has proved highly satisfactory in producing heavy yields of seed.

(5) Although the yield and quality of red clover seed crops in Montgomeryshire, a district with a long tradition of clover seed production, was below normal in 1980, the growing of pedigree grasses for seed in that district proved far less uncertain.

(6) The evidence as a whole would suggest that the growing of élite stock of pedigree seeds could be made a profitable undertaking in the hands of farmers who are willing to give proper attention to details. The evidence also suggests that it should be possible to produce and place these strains on the market at a price that should bring them within easy reach of all who desire to improve their pastures.

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A COMPARISON OF CLIMATIC DATA RECORDED AT THREE METEOROLOGICAL STATIONS IN CARDIGANSHIRE

DURING THE PERIOD OCTOBER, 1927, TO OCTOBER, 1930.

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The climatic data discussed in this paper are those of the meteorological stations at :—

C.G.—The Castle Grounds, Aberystwyth.
P.B.S.—The Welsh Plant Breeding Station Farm, Aberystwyth.
B.L.—Bank, Lletyevanhen, Elerch.

These three centres, though near to one another, differ considerably in the characteristics of their locations. C.G. is situated at Aberystwyth, 59 feet above sea level and within a few yards of the sea shore. P.B.S. is situated two miles in an E.N.E. direction from C.G. at an altitude of 452 feet; thus there is a steep incline from the sea level to this centre. B.L. is situated about eight miles from C.G. in an E.N.E. direction at an altitude of 900 feet. It stands on a ridge, the average height of which is about 750 feet, and which runs practically from east to west. The meteorological station on B.L. was erected in 1927, thus it is possible to give results for three years only, *i.e.*, from October, 1927, to October, 1930. These three centres may be

taken as typical of large areas in West Wales, C.G. representing the coastal lowlands, P.B.S. the coastal hills, and B.L. the upland limit of cultivation.

It is known that crops respond readily to changes in weather conditions, but the amount of data available relating to the specific action of weather conditions on plant life is scanty. With the object of comparing the effect of climate at P.B.S. and B.L. on the growth of crops, seeds of certain farm crops were sown at the two centres in the spring of 1929 and of 1930. Sowing was carried out in two types of soil at both centres, *viz.*, in the soil occurring at the centre and in soil carried from the other centre, in order to compare the effect of climate on the growth of crops in similar soils. Unfortunately the experiment failed owing to depredations of birds and mice.

TABLE I.

Showing the average monthly rainfall in inches at C.G., P.B.S., and B.L.

Month.	*C.G.*	*P.B.S.*	*B.L.*
January ...	3.59	4.73	4.66
February ...	1.29	1.73	1.76
March ...	1.45	1.78	1.74
April ...	1.08	1.25	1.68
May ...	1.68	2.07	2.08
June ...	2.97	3.95	4.72
July ...	2.87	3.68	5.21
August ...	3.31	5.10	5.92
September ...	2.63	3.02	2.92
October ...	4.75	6.04	6.33
November ...	5.19	6.78	6.48
December ...	3.64	4.84	4.06
Total ...	34.45	44.97	47.56
Total for summer months (June, July, and August) ...	9.15	12.73	15.85

Rainfall.

The rainfall data (*cf.* Table I and Fig. 1) show that the average rainfall for every month of the year was much lower at C.G. that at either of the other two centres. P.B.S. received 30 per cent. and B.L. 39 per cent. more rain than C.G. It is seen, however, that the excess of rain at P.B.S. and B.L. over that of C.G. was not uniform for every month (*cf.* Table II and Fig. 2). This is clearly seen when the figures for C.G. and P.B.S. for certain months are compared; P.B.S. had 54 per cent. more rain than C.G. in August and only 15 per cent. more in September. Again, comparing the figures recorded at C.G. and B.L.,

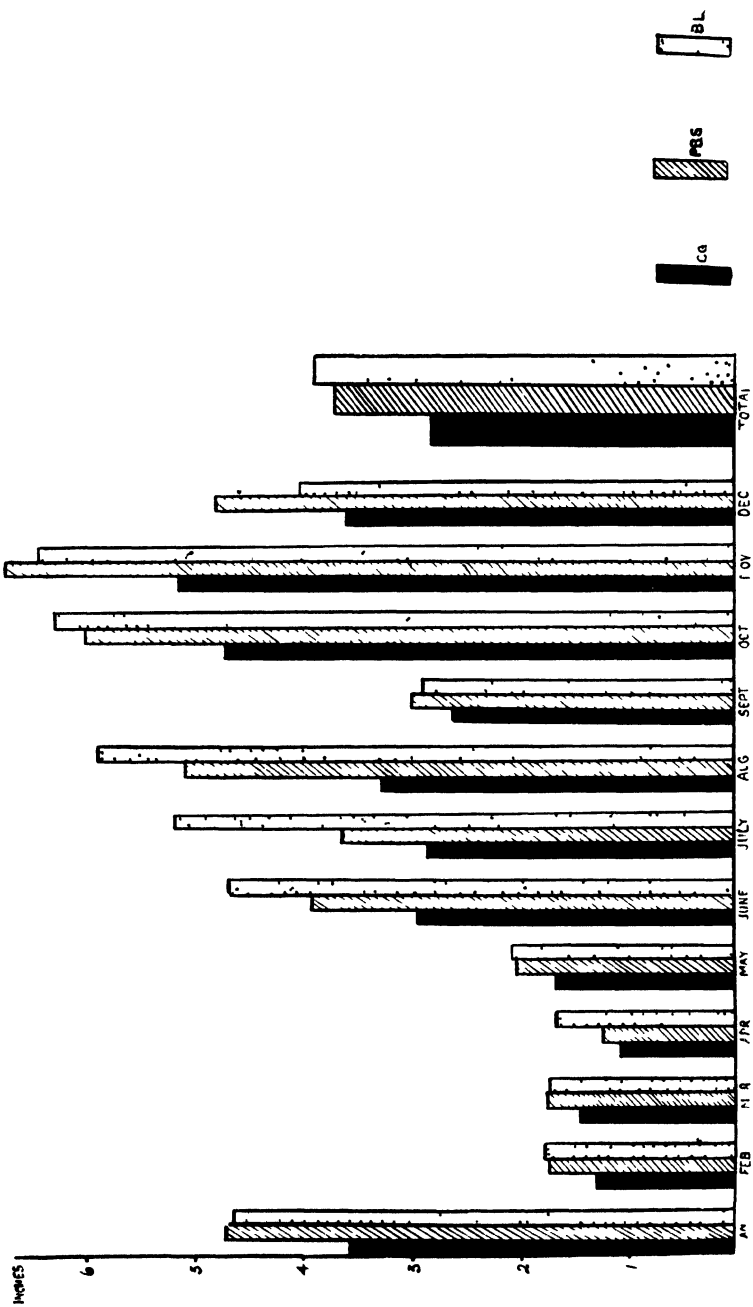


FIG. 1. Showing average rainfall per month (inches).

TABLE II.

Showing the average monthly rainfall at P.B.S. and B.L. as a percentage of that at C.G.

Month.	*P.B.S.* *Per cent.*	*B.L.* *Per cent.*
January ...	132	130
February ...	134	137
March ...	123	120
April ...	116	155
May ...	123	124
June ...	133	159
July ...	128	182
August ...	154	179
September ...	115	111
October ...	127	133
November ...	130	125
December ...	133	112
Total ...	130	139
Total for summer months (June, July, and August)	139	173

it is found that B.L. in July and August had 82 per cent. and 79 per cent. respectively more rain than C.G.; the figures for September and December show the excess of rain at B.L. over that at C.G. to be only 11 per cent. and 12 per cent. respectively. Lastly, the excess of rain at B.L. over that at P.B.S. was very pronounced in the three summer months (June, July and August), being about 25 per cent. In spring (March, April and May) it was 8 per cent. higher, while for the other six months the rainfall was actually lower at B.L. than at P.B.S.

TABLE III.

Showing the percentage number of rain days at C.G., P.B.S., and B.L.

	C.G. *Per cent.*	*P.B.S.* *Per cent.*	*B.L.* *Per cent*
(i) *Average per year.*			
Days with .01 inches of rain ...	54	61	55
Days with .04 inches of rain ...	41	43	46
(ii) *Average for June, July and August.*			
Days with .01 inches of rain ...	55	60	60
Days with .04 inches of rain ...	42	47	53

Table III shows the percentage number of rain days. It is seen that at P.B.S. the number of days in a year when some rain

was recorded was much higher than at either of the other two centres. On the other hand, the number of days on which 0.04 in. and upwards was recorded was highest at B.L. Further, it is seen from the table that during the summer months (June,

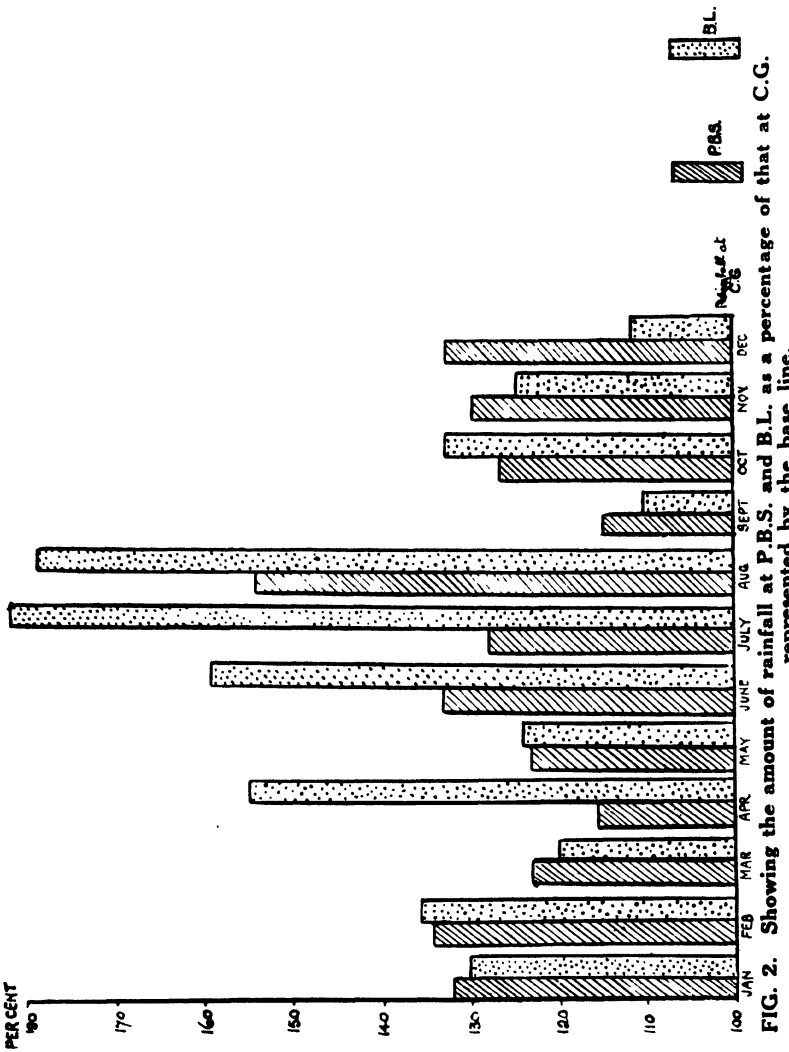
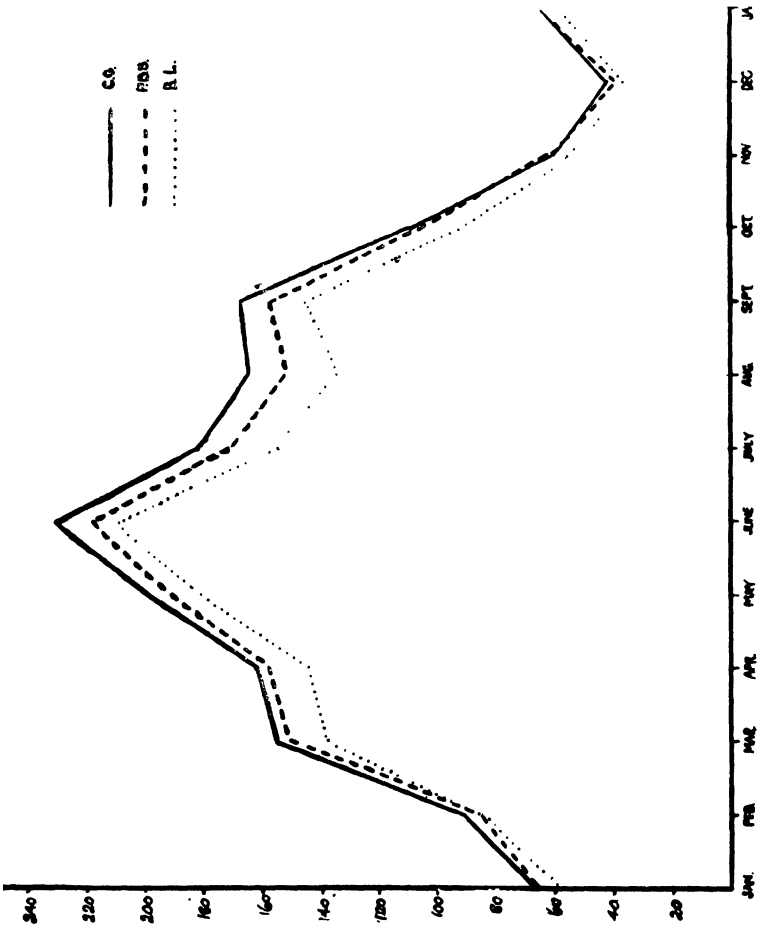


FIG. 2. Showing the amount of rainfall at P.B.S. and B.L. as a percentage of that at C.G. represented by the base line.

July and August) the number of days on which rain was recorded was as high at B.L. as at P.B.S., while the number of days on which 0.04 in. and upwards was recorded was considerably higher at B.L. than at P.B.S.

TABLE IV.
Showing the average monthly direct sunshine in hours at C.G., P.B.S. and B.L.

Month.	*C.G.*	*P.B.S.*	*B.L.*
January ...	65.3	65.8	57.9
February ...	90.8	86.8	85.2
March ...	154.1	151.1	187.7
April ...	161.1	157.5	144.4
May ...	198.7	190.7	180.8
June ...	230.1	218.0	209.4
July ...	181.9	172.1	154.3
August ...	166.4	152.6	135.8
September ...	168.8	158.5	146.1
October ...	110.3	107.1	92.5
November ...	61.3	62.2	56.8
December ...	42.8	40.7	36.8
Yearly average ...	1631.4	1562.1	1487.2



GRAPH 1. Showing the average direct sunshine per month (in hours).

Sunshine.

A comparison of the number of hours of direct sunshine (*cf.* Table IV and Graph 1) shows that for three years under consideration C.G. received over 4 per cent. more than P.B.S. and 12 per cent. more than B.L.; the latter difference is considerable and important. This higher amount, however, is not evenly distributed throughout the year (*cf.* Table V and Fig. 3). For the winter months October to April inclusive (with the exception of December and February) the difference between C.G. and

TABLE V.

Showing the average monthly direct sunshine at P.B.S. and B.L. as a percentage of that at C.G.

Month	*P.B.S.*	*B.L.*
January	100	89
February	95	94
March	98	89
April	98	90
May	96	91
June	95	90
July	95	85
August	92	82
September	94	87
October	97	84
November	101	93
December	95	86

P.B.S. is less than 3 per cent.; whereas from May to September it ranges from 4 per cent. to 8 per cent., the maximum difference occurring in August. Again on comparing C.G. and B.L. the same irregularity is noted; the direct sunshine at B.L. being 15 per cent. and 18 per cent less in July and August respectively, and 6 per cent. less in February than at C.G.; that is to say, at C.G. the number of hours of direct sunshine per annum exceeded that at B.L. by 194, but of this number 58 hours (nearly one-third of the amount) were recorded during the two months July and August, *i.e.*, an average of nearly an hour's extra sunshine per day.

Temperature.

There is nothing outstanding in these data (*cf.* Table VI). Owing to the difference in altitude the average temperature at all seasons at B.L. (900 feet) is about 3°F. lower than at C.G. and at P.B.S. (450 feet) it is approximately 1.5°F. lower than at C.G.

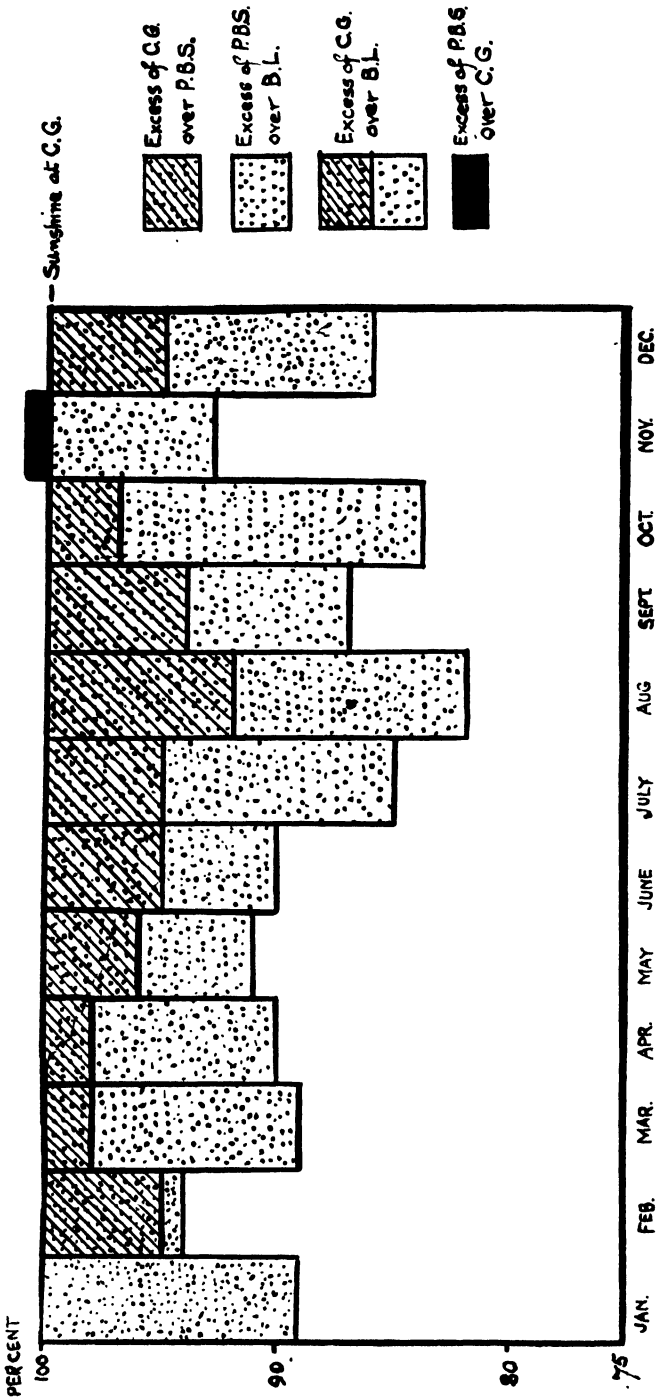


FIG. 3. Showing the amount of direct sunshine at P.B.S. and B.L. as a percentage of that at C.G.

TABLE VI.

Showing the average monthly temperature in degrees Fahrenheit at C.G., P.B.S., and B.L.

Month.	*C.G.*	*P.B.S.*	*B.L.*
January ..	41.3	39.4	38.7
February ..	39.8	38.5	37.6
March ..	43.6	42.9	42.2
April ...	46.3	45.3	44.0
May ...	52.0	50.8	50.9
June ...	55.8	51.5	53.6
July ..	59.3	57.9	55.7
August ..	59.1	57.6	56.2
September	57.9	56.4	55.0
October ..	52.6	50.6	49.0
November ...	46.9	45.4	43.6
December ...	41.2	39.5	38.5
Average per annum ...	49.7	48.2	46.9

Discussion of results.

As the data only cover a period of three years, definite conclusions cannot be drawn. Notwithstanding this it may be of interest to refer to certain points.

The annual rainfall at C.G. was 34½ in., at P.B.S. 45 in. and at B.L. 47½ in. All three stations are exposed to the moisture-laden south west winds, so that a fairly heavy rainfall would be expected. The difference of 10½ in. between C.G. and P.B.S. is probably due to the sharp gradient up which the S.W. wind is forced to rise and this partly accounts for the high percentage (61 per cent.) of days on which rain was recorded at P.B.S. B.L. on the other hand, is situated 8 miles inland on an E.-W. ridge, which rises gradually as it runs inland. This would tend to give it a lower rainfall than P.B.S., but B.L. is at an altitude of 900 feet and thus it often lies within the rain cloud layer, which probably accounts for the large number of days with a rainfall exceeding 0.04 in. The position of B.L. would also account for the decrease in the amount of direct sunshine, the clouds settling as a veil on these high areas for a considerable time; thus on June 8th, 1927, C.G. and P.B.S. had 8 hours more sunshine than B.L., where the recorder noted " blue sky with heavy clouds " at 9 a.m. on that date.

Comparison of present data with previous data.

The significance of differences in the climatic data at the three centres discussed in the present paper are well brought out

by comparison with data recorded at Aberystwyth for the period 1894-1927.[1] (See Table VII).

The total rainfall at C.G. approximates to that of the " medium " years, while that at P.B.S. and at B.L. approximates to that of " wet " years.

TABLE VII.

Comparison of climatic data recorded at C.G., P.B.S., and B.L., from October, 1927, to October, 1930, with data recorded at Aberystwyth during the period 1894–1927.

Data recorded at Aberystwyth.		*Data recorded at C.G., P.B.S. and B.L.*	
Years.	*Amount.*	*Centre.*	*Amount.*
	(a) Total rainfall per annum (in inches).		
Dry.	25.69	**C.G.**	34.45
Medium.	33.18	**P.B.S.**	44.97
Wet.	45.56	**B.L.**	47.56
	(b) Summer rainfall (June, July, and August) (in inches)		
Dry.	7.24	**C.G.**	9.15
Medium.	8.47	**P.B.S.**	12.73
Wet.	12.67	**B.L.**	15.85
	(c) Number of rain days (.01 inch +).		
Dry.	193	**C.G.**	199
Medium.	202	**P.B.S.**	224
Wet.	232	**B.L.**	201
	(d) Average daily sunshine per annum (in hours).		
Dry.	4.57	**C.G.**	4.47
Medium.	4.07	**P.B.S.**	4.28
Wet.	3.67	**B.L.**	3.91
	(e) Temperature (degrees Fahrenheit).		
Dry.	50.8	**C.G.**	49.7
Medium.	50.3	**P.B.S.**	48.2
Wet.	48.9	**B.L.**	46.9

The difference between the average rainfall of " dry " and " wet " years for the summer months (June, July and August) is less than that between C.G. and B.L. for the three years under consideration.

The number of rain days at C.G. and B.L. approximates to that of " medium " years, whilst the number of rain days at P.B.S. was nearly as high as in the average " wet " years.

The average daily sunshine varies more as between " dry " and " wet " years than as between C.G. and B.L., while the difference between the latter was greater than that between either " dry " and " medium " years or " medium " and " wet " years.

[1] Jones, M. G. Meteorological conditions at Aberystwyth, 1894-1927. *Welsh Journ. Agric.*, IV, 1928.

The difference in the average yearly temperature is greater between C.G. and B.L. than between "dry" and "wet" years.

It is thus evident that if differences in climatic conditions as between two years control the growth of crops in any one year the different climatic conditions existing at C.G., P.B.S., and B.L. must also have an appreciable effect on their growth. This problem will be the subject of further investigation.

Acknowledgements.

Grateful acknowledgement is made to Mr. Whitehouse, M.Sc., for helpful suggestions and criticism in connection with some aspects of this paper. Thanks are due to Mr. Osborne J. Evans, Health Department, Aberystwyth, for placing at the writers' disposal certain data recorded at the Castle Grounds Station, Aberystwyth. Thanks are also due to Mr. J. W. Watkins and Miss M. M. Evans, who have been responsible for taking the records at the Plant Breeding Station Farm and at Bank, Lletyevanhen, respectively.

THE DISTRIBUTION OF THE NITROGENOUS AND MINERAL CONSTITUENTS IN THE OAT PLANT AT DIFFERENT STAGES OF GROWTH.

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and

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Oats is by far the most important cereal crop in Wales. In 1923, when the present investigation was undertaken, nearly 195,000 acres were grown and this represented about two-thirds of the total area under the cereal crops.

The predominance of oats in the Welsh farming system may be mainly attributed to two factors. First there is the climatic conditions of the country which is better suited for the growing of oats than any other cereal and oats being a hardy crop it can be grown with success up to an altitude of a thousand feet. Secondly, Wales is pre-eminently a stock raising country and a cereal crop such as oats is absolutely essential for the maintenance of the livestock especially horses and cattle.

In view of the important position occupied by the oat crop in the Principality it was felt that an investigation should be made into the chemical composition of the different varieties grown in the College Area. This investigation has been in progress for the last seven years, and its main object was to determine the suitability of certain varieties of oats for particular districts and localities, and to ascertain whether locality has any influence on their chemical composition.

One of the objectives of the investigation was to ascertain the nature and extent of the changes taking place in the chemical composition of the oat plant during its later vegetative and grain forming periods, and this paper deals mainly with the distribution of the nitrogenous and mineral constituents in the plant at different stages of growth. For the investigation four varieties of oats were selected, two suitable for upland districts Ceirch du Bach and Strigosa (blew geirch or ceirch llwyd bach) and two lowland varieties Victory and Record.

These were grown at the Welsh Plant Breeding Station on the Penglais Field which is situated on a slope facing south west at an altitude of 260 feet.

The soil of the Penglais Field is sedentary in character and contains a relatively high percentage of fine silt, a little clay with a fair proportion of the coarser grained particles. Chemically it is well supplied with organic matter and potash but is poor in phosphate and lime, though early in 1923 it received a dressing of Basic Slag at the rate of 6 cwt. per acre.

The general meteorological conditions during the growing season of 1923 are given in the Table below :—

	Apr.	*May*	*June*	*July*	*Aug.*	*Sept.*
Rainfall in inches ...	2.41	3.64	1.17	4.51	3.53	1.70
Number of rainy days	19	21	11	17	23	22
Sunshine in hours ...	148	196	145	136	140	134
Average number of hours' sunshine per day ..	5.5	7.0	6.0	5.5	5.5	5.5

The rainfall during the growing period from April to the end of August amounted to 15.3 inches, of which over 50 per cent. fell in July and August. While May was exceptionally sunny, the driest month was June, and the weather at the time of ripening was wet and unfavourable.

The oats were sown on April 14, 1923, at the rate of three grains per inch in rows 13½ feet long and one foot apart. Each variety had allocated to it six rows so arranged that no two

neighbouring rows were of the same variety. It was decided to take samples for analysis at the following stages of growth :—

Stage 1. Panicle just beginning to emerge.

Stage 2. Panicle fully emerged.

Stage 3. The milky stage, *i.e.*, the glumes had lost their green colour from the tip half way down.

Stage 4. The under ripe stage, *i.e.*, the glumes of the lower two nodes of the panicle still showed some green colour, but no green colour showed on the glumes above the lower two nodes.

Stage 5. The ripe stage, *i.e.*, no green colour showing on any glumes.

The first set of samples consisting of 100 tillers of each variety cut about three inches from the ground was taken in July. The green weight of these was immediately determined and the samples subsequently separated into stem, leaf and panicle. Owing to the loss of moisture during this separation, it was deemed inadvisable to attempt to determine the green weight of these separations, though their dry weight at the different stages of growth was determined. In the case of the four varieties the above stages of growth were reached at different times with the result that as shown in Table 1 the dates of sampling varied.

TABLE I.

Showing the date at which the four varieties of oats were sampled.

Stage of growth.	*Ceirch du Bach.*	*Strigosa.*	*Victory.*	*Record.*
Stage 1	July 13, 1923	July 9, 1923	July 9, 1923	July 7, 1923
,, 2	July 21, 1923	July 11, 1923	July 14, 1923	July 11, 1923
,, 3	Aug. 22, 1923	Aug. 10, 1923	Aug. 6, 1923	Aug. 1, 1923
,, 4	Aug. 28, 1923	Aug. 16, 1923	Aug. 21, 1923	—
,, 5	Sept. 4, 1923	Aug. 22, 1923	Sept. 3, 1923	Aug. 25, 1923

Strigosa and Record with a growing period of 130 and 133 days respectively are seen to be the earliest varieties to reach the ripe stage, while Victory and Ceirch du Bach are nearly a fortnight later with a growing period of 142 and 143 days. The Table further shows that Ceirch du Bach and Strigosa once they reach the milky stage ripen very much more rapidly than the other two varieties, though after the development of the panicle both Victory and Record attain the milky stage in shorter time. It is to be remembered in this connection that the stage referred to as milky was determined as already indicated by the colour of the glume.

As our aim in sampling was to obtain panicles as nearly as possible at the same morphological and physiological stages of growth, a difficulty was experienced in obtaining uniformity between the samples. The natural tendency was for a greater proportion of the best tillers—that is those which shot out first—to be cut for the earlier samples, with the result that the latter samples were rather poorer. This possibly affected not only the weights of the samples, but also to some extent when each subsequent growth stage could be sampled. The yields, therefore, taken at the earlier stages of growth are not strictly comparable witn those taken later, and for this reason too much stress is not laid on the yield data. However, they are significant of the different tendencies of the four varieties, and show the general trend of the variation taking place with increasing maturity. In view of this, the yields are not discussed in detail but attention is drawn to a few broad generalisations that may reasonably be drawn from them.

TABLE II.

Showing the yield of green and dry matter in grams. per 100 tillers at different stages of growth, together with the percentage of dry matter.

	Ceirch du bach.			*Strigosa.*		
Stage of growth.	*Green*	*Dry*	% *Dry matter.*	*Green*	*Dry*	% *Dry matter.*
Stage 1	906	153	16.8	600	112	18 7
,, 2	1072	217	20.3	609	131	22.1
,, 3	810	291	36.0	636	225	35.4
,, 4	668	246	36.3	532	218	40.9
,, 5	479	236	49.2	401	215	53.2

	Victory.			*Record.*		
Stage of growth.	*Green*	*Dry*	% *Dry matter.*	*Green*	*Dry*	% *Dry matter.*
Stage 1	1525	257	16 8	1097	204	18.6
,, 2	1610	292	18.1	1135	238	20.9
,, 3	1781	477	26 7	1194	388	32.5
,, 4	1162	421	36.2	—	—	—
,, 5	892	429	48.2	669	389	58.1

Examination of the Table shows that the maximum yield of green matter in all but Ceirch du bach is obtained at the milky

stage, and that after this there is a fall in the green weight of all. This decrease in weight of green matter is largely accounted for by the rapid desiccation that sets in after the milky stage is reached.

The yield of dry matter in all four varieties increases up to the milky stage, and though after this the yield is less, it remains fairly constant. The loss in yield of dry matter subsequent to the milky stage, is partly due to the error introduced in sampling already referred to. Other factors, however, which may to some extent account for the loss are the mechanical loss of leaves, leaching of certain constituents by rain and loss of dry matter by respiration.

One of the most striking changes in composition that takes place with advancing maturity is the increase in percentage of dry matter. This is fairly regular in all four varieties up to the under-ripe stage, after which desiccation becomes more rapid.

The quantitive distribution of the dry matter between the stem, leaf and spikelet of the plant have been calculated on the basis of taking the yields of the constituents in the whole plant as 100 at each stage, that is, the proportions in the stem leaf and spikelet respectively add up to 100. The method of sampling adopted does not affect these results, or at most only to a very small extent, for the yield of dry matter in the leaf, stem and spikelet respectively relative to one another are strictly comparable at each stage of growth.

The dry matter at the beginning of the emergence of the panicle is so distributed quantitatively in the oat plant that approximately 36 per cent. is in the stem, a little under 50 per cent. in the leaf and the remainder in the spikelet. As the panicle further develops and ripens the relative percentage in the leaf decreases steadily up to the ripe stage when only about 16 per cent. remains.

The fluctuation in the stem is not so great as in the leaf or spikelet. Thus in Ceirch du bach and Strigosa the relative percentage of dry matter rises up to the stage when the panicle is fully emerged, while in Victory and Record it continues up to the milky stage. Subsequently in the stems of all four varieties the percentage declines, so that at the ripe stage there is relatively less dry matter in the stem than when the panicle first emerged. This presumably is largely due to increase in the dry matter of the spikelet rather than an actual reduction in absolute dry matter in the stem.

The relative amount of dry matter in the spikelet increases throughout the growing period, especially is this the case between

the stage at which the panicle is fully emerged and the milky stage. This increase is particularly marked in the varieties Ceirch du bach and Strigosa where the amounts of dry matter

TABLE III.

Showing the percentage distribution of the dry matter between the stem, leaf, and spikelet of the four varieties.

Stage of growth.	*Ceirch du bach.*			*Strigosa.*		
	Stem	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	35.29	49.67	15 03	35.55	48.90	15.55
,, 2	41.04	36.70	19.26	40.90	37.18	21.93
,, 3	34.35	19.05	46.60	37.34	19 56	43 10
,, 4	31.71	18.70	49.59	34.86	17.89	47.24
,, 5	31.36	18 64	50.00	34.89	15.81	49.31

Stage of growth.	*Victory.*			*Record.*		
	Stem	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	36 97	47.48	15.56	35.51	47.80	16 66
,, 2	42 46	36 30	21.24	41 95	35.24	22.82
,, 3	43 19	20.13	36 68	42 52	21.92	35 56
,, 4	31 83	16.86	51.31	* —	—	
,, 5	31 70	15.85	52 45	31.88	15.17	52.95

* Unfortunately the samples of dry matter of Record at the under-ripe stage were damaged in storage and the results could not be relied on

are only 3.5 and 6 per cent. less at this stage than they are when the plants are fully ripe. In Victory and Record, however, the differences between the milky and fully ripe stages are of the magnitude of 15 and 17 per cent.

The sampling at the milky stage as previously explained was based on the disappearance of the green colour from the apical parts of the glumes, and these results suggest that this occurred in Ceirch du bach and Strigosa at a latter stage in the development of the spikelet than was the case in the varieties Victory and Record.

Although at the milky stage the varieties differ considerably in their percentage of dry matter in the spikelet there is close agreement amongst them in this respect at the under-ripe and full-ripe stage, when approximately 50 per cent. of the dry

matter of the whole plant in the four varieties is found in the spikelet[1].

When it is remembered that Ceirch du bach and Strigosa are regarded as straw-producing varieties, while Victory and Record are classed as grain producers such a result is certainly unexpected. Record and Victory certainly show a slightly higher average proportion of dry matter than Ceirch du bach and Strigosa but it cannot be regarded as in any way significant. One reason that may be suggested for this disagreement with expectation is that in actual farm and field practise the proportion of heads in the truly ripe stage in the varieties Victory and Record may be greater than in the varieties Ceirch du bach and Strigosa, for the latter tiller more freely and therefore contribute to the final crop when cut, a larger proportion of heads in a slightly under ripe stage.

The next constituent discussed is the crude protein the quantitative distribution of which throughout the plant is shown in Table IV.

TABLE IV.

Showing the percentage distribution of crude protein between the stem, leaf, and spikelet.

	Ceirch du bach.			*Strigosa.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	16.78	63.16	19.76	18.31	61.53	20.12
,, 2	20.33	51.64	28.03	22.16	48.65	29.19
,, 3	11.52	18.80	69.68	12.23	22.66	65.11
,, 4	9.20	17.79	73.01	10.25	19.08	70.67
,, 5	6.51	18.63	74.83	6.95	16.60	76.45

	Victory.			*Record.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	18.20	59.88	21.92	19.64	60.71	19.64
,, 2	23.12	46.83	30.03	24.51	49.30	26.20
,, 3	17.55	23.62	58.83	21.16	27.21	51.63
,, 4	9.55	14.03	77.43	—	—	—
,, 5	7.97	14.96	77.06	7.71	10.84	81.45

At that stage of development of the plant when the panicle is beginning to emerge, the leaf contains by far the largest

[1] "Breeding Cereals for increased production". Beavan, *Journ. Farmers' Club*, November, 1920.

proportion of crude protein, amounting as it does to approximately 60 per cent. of the whole plant. As maturity advances it decreases in a marked manner especially between that period of growth when the panicle is fully emerged and the milky stage. This decrease continues up to the ripe stage when it forms on the average but 15 per cent. of that of the whole plant.

In the stem the crude protein is at its maximum when the panicle is fully emerged, subsequent to this it rapidly falls with the result that at the ripe stage it forms on the average of the four varieties only 7 per cent. of that of the whole plant.

The greatest transference of crude protein from the stem and leaf into the spikelet takes place at that period of growth between the full emergence of the panicle and the milky stage. This continues up to the fully ripe stage when 77 per cent. of the total protein of the plant is found in the spikelet.[2]

The distribution of the mineral matter between the parts of the plant is on the whole analogous to that of the dry matter (compare Tables V and III), but differs slightly in the relative proportions present in the stem, leaf and spikelet.

TABLE V.

Showing the percentage distribution of mineral matter or ash in stem, leaf, and spikelet.

	Cerch du bach.			*Strigosa.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	35.97	54 86	9.18	33.82	57 33	8.85
,, 2	41 07	47.31	11 62	36.61	50 68	12 70
,, 3	41 57	21.71	30.73	39.60	27.15	33 26
,, 4	41.57	23.08	35.57	38.82	22 73	38 46
,, 5	39 67	22 03	38 31	40.83	19 61	39.56

	Victory.			*Record.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	34 23	53.35	12 42	36.23	53.08	10.70
,, 2	38.24	49.82	11.94	40.58	46 63	12.78
,, 3	36.76	31.69	31.54	35.73	29 80	34.47
,, 4	35 87	23.72	40.41	–	—	
,, 5	38.63	20.79	40.57	35.70	16.28	48.02

[2] Brenchley, W. E., and Hall, A. D. "The development of a grain of wheat". *Journ. Agric. Sci.*, 3, Part II, pages 196 217.

In the stem the relative percentage of mineral matter shows but little deviation throughout the growing period. The maximum proportion of mineral matter in the stem of Ceirch du bach is reached at the milky stage, in Strigosa it tends to increase with maturity to the final ripening, in Victory it remains practically constant from the stage where the panicle is fully formed. while in Record it tends to decline from this stage onwards.

The net result of the fluctuations is that there is a greater proportion of mineral matter present in the stem at the ripe stage than there is when the panicle begins to form.

The relative percentage of mineral matter increases throughout the whole period of growth in the spikelet, the increase being from approximately 10 to 41 per cent., while the fall in the leaf during the same period is from roughly 50 to 20 per cent.

TABLE VI.

Showing the percentage distribution of phosphoric acid between the stem, leaf, and spikelet.

	Ceirch du bach.			*Strigosa.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	32.09	13.15	24.76	31.26	42.00	26.73
,, 2	41.69	30.32	27.96	36.10	31.95	31.95
,, 3	10.66	10.26	79.07	6.57	8.73	84.70
,, 4	8.69	11.12	80.19	4.41	10.13	85.43
,, 5	6.07	7.72	86.20	2.36	5.23	92.40

	Victory.			*Record.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	34.67	39.03	26.31	26.34	39.25	34.40
,, 2	37.16	30.22	32.62	36.43	26.63	35.95
,, 3	22.19	12.76	64.76	24.96	15.00	60.02
,, 4	8.99	6.98	84.02	—	—	–
,, 5	6.29	7.18	86.11	5.12	6.16	88.70

The phosphoric acid is more evenly distributed between the stem, leaf and spikelet at the beginning of the emergence of the panicle than any other constituent. The leaf at this stage contains 40 per cent. of the phosphoric acid of the plant, though as maturity approaches it rapidly falls. This fall in the phosphoric acid of the leaf is very pronounced in the period between the panicle's full formation and the milky stage, and at the ripe

stage it is so reduced in the leaf as to form but approximately 6 per cent. of that of the whole plant.

The proportion of phosphoric acid in the stem is at its maximum when the panicle is fully emerged, and at this period of growth shows a marked increase over that present in the stem at the emergence of the panicle. Subsequent to this a very rapid decline sets in so that at the ripe stage only 5 per cent. of the whole is found in the stem. This depletion of the stem in phosphoric acid though common to all is much more complete in Strigosa than any other variety.

The relative proportion of phosphoric acid in the spikelet increases with maturity, and on the average at the ripe stage 88 per cent. of the whole is found in the spikelet. The migration of phosphoric acid from the stem to the spikelet is more complete than that of any other constituent. Thus in Strigosa at the ripe stage 92.4 per cent. of the total phosphoric of the plant is in the spikelet.

TABLE VII.

Showing the percentage distribution of lime between the stem, leaf, and spikelet.

	Cerch du bach.			*Strigosa.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	15.55	76.59	8.86	12.71	77.93	9.36
,, 2	17 15	71.86	10 99	11 00	74.67	11.33
,, 3	18.75	52.77	28.48	22.42	52.86	24.73
,, 4	19.79	52.41	27.80	23.05	46.76	30.20
,, 5	19.84	48.38	31.77	20 11	12 71	37.15

	Victory.			*Record.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	12.84	80.71	6.46	13.52	76.61	9.87
,, 2	16.60	73.57	9.83	15.24	72.87	11.89
,, 3	24.49	54.73	20.77	22.02	54.53	23.45
,, 4	23.50	51.80	24.70	—	—	–
,, 5	28.06	46.50	25.44	19.33	42.22	38.44

At the beginning of the emergence of the panicle nearly 80 per cent. of the total lime of the plant is present in the leaf, an amount considerably in excess of any other constituent. This preponderance of lime in the leaf is maintained throughout the

life of the plant, and although steadily falling with maturity, still at the ripe stage contains on the average 45 per cent. of the total.

From 13 to 15 per cent. of the total lime is present in the stem at the beginning of the emergence of the panicle and this proportion steadily rises in all varieties up to the milky stage. Subsequent to this it remains practically constant in Strigosa and Record, while in Ceirch du bach and Victory the proportion of lime in the stem increases slightly.

At all periods of growth the relative percentage of lime in the spikelet remains low, the average proportions at the first and last stages of growth examined being approximately 8 and 33 per cent. respectively. It is noteworthy that these proportions of lime in the spikelet are lower than any other constituent with the exception of chlorides. From this it is seen that the transference of lime from the straw to the spikelet is very incomplete in all varieties, and in Victory is less than in any other variety.

TABLE VIII.

Showing the percentage distribution of potash between the stem, leaf, and spikelet.

Stage of growth.	*Ceirch du bach.*			*Strigosa.*		
	Stem	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	39.94	15.11	14.55	—	—	—
,, 2	11.32	41.54	17.14	15.37	31.10	20.52
,, 3	11.07	23.20	35.73	12.65	28.18	29.17
,, 4	32.30	22.50	45.28	11.39	22.88	35.73
,, 5	28.53	22.89	48.60	15.97	18.79	35.24

Stage of growth.	*Victory.*			*Record.*		
	Stem	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	31.19	18.71	17.10	37.36	44.61	18.03
,, 2	10.95	10.77	18.27	36.06	45.11	18.54
,, 3	16.00	25.73	27.28	36.36	29.25	34.40
,, 4	11.92	18.90	39.17	—	—	—
,, 5	36.76	13.92	49.32	33.06	16.53	50.41

The distribution of potash in the different parts of the oat plant at the beginning of the development of the panicle is such that the leaf contains 45 to 50 per cent., the stem 35 to 40 per cent. and the spikelet the remaining 15 to 18 per cent. As the

plant matures there is a steady decrease in the relative amount contained in the leaf with the result that at the ripe stage it is reduced to about 18 per cent.

The variation in the proportion of potash in the stem shows a difference among the varieties at the various stages of growth examined. Thus in Ceirch du bach after a gain in the initial stage there is a steady fall which becomes more pronounced after the milky stage, though in Strigosa a more or less constant value is maintained from the formation of the panicle to the ripe stage.

The relative percentage of potash in the spikelet steadily increases with maturity so that at the ripe stage Ceirch du bach, Victory and Record have approximately the same proportion of potash, namely, 50 per cent. In Strigosa the transference of potash into the spikelet has not been so complete with the result that only 35 per cent. of the total is found in the spikelet at the ripe stage.

TABLE IX.

Showing the percentage distribution of iron between the stem, leaf, and spikelet.

	Ceirch du bach.			*Strigosa.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1		-			-	-
,, 2	27.15	47.95	24.92	41.53	42.51	12.96
,, 3	24.45	29.07	48.48	28.66	41.13	30.22
,, 4	25.95	36.19	37.86	26.12	28.18	35.10
,, 5	24.35	37.01	38.64	26.00	25.00	39.00

	Victory.			*Record.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	30.72	53.58	15.60	27.88	54.43	17.70
,, 2	33.33	46.81	19.85	35.22	47.75	17.03
,, 3	34.50	33.59	31.91	35.68	30.14	34.16
,, 4	32.75	29.63	37.63		—	—
,, 5	27.21	32.30	40.49	31.49	25.52	13.00

Of the total iron of the plant at the beginning of the panicle formation, slightly over 50 per cent. is present in the leaf. It falls in the leaf of all varieties with advancing maturity though in rather an irregular manner. Thus in Record the relative percentage of iron in the leaf falls up to the ripe stage, in Ceirch

du bach, on the other hand, the minimum is at the milky stage, whereas in Strigosa and Victory it is at the under ripe stage.

The proportion of iron in the stem of Victory and Record remains fairly constant throughout the period of growth, fluctuating slightly about the mean figure of 33 per cent. of the total. The tendency in Ceirch du bach and Strigosa is for the iron to fall especially in Strigosa.

In the spikelet, the relative percentage of iron rises steadily up to the ripe stage in all varieties except Ceirch du bach, which attains its maximum a little earlier at the milky stage. The proportion on the average increases from approximately 16 per cent. at the beginning of panicle formation to 40 per cent. at the ripe stage.

Generally speaking the iron may be said to be more evenly distributed throughout the plant than any other constituent. From the milky stage onwards the variation in the distribution of this constituent is small, and at the ripe stage the leaf and stem on the average contain about 30 per cent. of the total iron with about 40 per cent. in the spikelet.

TABLE X.

Showing the percentage distribution of chlorides as chlorine between the stem, leaf, and spikelet.

	Ceirch du bach.			*Strigosa.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1			—	59.38	33.96	6.65
,, 2	63.46	31.74	1.80	67.39	27.47	5.14
,, 3	76.70	18.25	5.05	71.99	20.33	7.68
,, 4	75.46	17.73	6.80	81.23	13.88	4.89
,, 5	83.91	8.21	7.82	81.88	14.16	3.95

	Victory.			*Record.*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	56.98	40.56	2.47	55.83	39.81	4.23
,, 2	64.16	33.16	2.67	64.06	32.51	3.43
,, 3	62.09	29.59	8.32	58.50	33.52	7.99
,, 4	74.24	14.94	10.83	—	—	-
,, 5	83.50	11.23	5.27	86.49	8.61	4.90

The distribution of chlorine in the oat plant is in many respects peculiar. In common with other constituents, the relative percentage of chlorine in the leaf falls steadily with

advancing maturity of the plant. The proportion in the leaf at the beginning of the formation of the panicle varies in the different varieties from 34 to 40 per cent., while at the ripe stage it has fallen to from 8 to 14 per cent.

The stem of the oat plant is very rich in chlorine, in which from 55 to 60 per cent. of the total amount is present at the beginning of the emergence of the panicle. The proportion of chlorine rises steadily through all the stages of growth until at the ripe stage 80 per cent. of the total is present in the stem. This variation in the distribution of the chlorine is peculiar to itself; for with no other constituent is there a marked rise in the proportion in the stem subsequent to the milky stage. This result is not apparently due to the stem receiving chlorine from the leaf or spikelet or both, for in Ceirch du bach and Strigosa the actual weight of chlorine in the stem is at a maximum at the milky stage, after which a loss occurs. The most probable explanation of this is that the loss of chlorine which takes place from the whole plant after the milky stage is relatively less in the stem than in the leaf and spikelet.

In the spikelet the proportion of chlorine is very small at all stages of growth, and the variation is very irregular in the different varieties. On the average at the ripe stage, the spikelet contains but 5.5 per cent. of the total chlorine of the plant. On comparing this figure with that of the other constituents at this stage, it is seen that it is exceptionally low being but one-sixth of the lime, which is the next lowest.

As previously stated the yields of the samples taken at the earlier stages are not strictly comparable to those at the later stages, and for this reason too much stress cannot be laid upon the yield data. However, the yields of dry matter and of its constituents at different stages of growth are so striking in certain cases as to warrant a few broad generalisations being drawn from them.

In the whole plant the yield of dry matter increases up to the milky stage and subsequently shows a slight loss, this on the average in the four varieties being 9 per cent. This loss is probably largely due to method of sampling and probably partly to certain other factors such as mechanical loss of leaves, leaching of certain constituents due to the action of rain and dew and to loss of dry matter by respiration.

In the case of certain constituents, however, the losses which occur after the milky stage appear to be too large to be accounted for by the above factors. This is apparently true of lime, potash and chlorine as seen from the following Table.

TABLE XI.

Giving the average weight in grams of lime, potash, and chlorine in the whole plant at the milky and ripe stages respectively.

Stage of growth.	*Lime (CaO)*	*Potash (K_2O)*	*Chlorine (Cl)*
Milky stage ..	1.14	6.36	1.87
Ripe stage ...	0.79	4.62	1.26

The Table shows that a very pronounced loss of these constituents occurred during the period milky to ripe stages of growth, amounting to 31, 27 and 33 per cent. in the case of lime potash and chlorine respectively. It is probable that these constituents pass from that portion of the plant above ground to the root and are possibly returned to the soil during the later ripening stages of the plant. The losses cannot wholly be accounted for by the sampling for they are approximately three times as great as that of the dry matter. Again if considerable mechanical loss of leaf had occurred the percentage loss of lime should be relatively much greater than that of the other constituents because the leaf is comparatively much richer in lime than potash and chlorine. Finally leaching cannot account for all the loss, for this, except in the case of chlorine, is almost entirely from the stem and leaf with little if any from the spikelet.

It is of interest to compare the ratios between certain of the constituents in the stem, leaf and spikelet at different stages of growth. These have been calculated and are shown in Table.

TABLE XII.

Giving the average ratio in the four varieties of nitrogen to phosphoric acid, nitrogen to lime, and of phosphoric acid to lime, in the stem, leaf, and spikelet at various stages of growth.

	Ratio of Nitrogen to Phosphoric Acid N/P_2O			*Ratio of Nitrogen to Lime N/CaO*			*Ratio of Phosphoric Acid to Lime P_2O/CaO*		
Stage of growth.	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*	*Stem*	*Leaf*	*Spikelet*
Stage 1	1.8	5.0	2.4	4.6	0.27	8.2	2.51	0.54	3.5
,, 2	1.8	5.1	2.6	4.6	0.21	8.1	2.50	0.42	3.0
,, 3	3.1	5.5	2.3	2.5	0.15	8.9	0.95	0.29	3.9
,, 4	4.1	5.3	2.6	2.0	0.14	11.5	0.51	0.31	4.0
,, 5	4.9	6.6	2.5	1.7	0.16	11.4	0.39	0.25	4.6

The ratio of nitrogen to phosphoric acid in the stem rises in all four varieties as the plant matures, while in the spikelet it remains approximately constant at all stages. Thus the migration of nitrogen and phosporic acid from the straw into the spikelet takes place simultaneously. The material also, of which the spikelet is built up in the varieties experimented with, contains nitrogen and phosphoric acid in the proportion of approximately 2.5 of nitrogen to one of phosphoric acid.

In the leaf the ratio on the average tends to rise with age, though this is not the case in all varieties. Thus in Ceirch du bach and Strigosa it widens as the plant matures, the greatest difference occurring between the under ripe and ripe stages, in Victory and Record, on the other hand, it maintains a constant value at all stages.

The ratio of nitrogen to lime falls steadily in the stem and leaf as the plant matures, while in the spikelet the ratio increases with maturity although it remains fairly constant until the milky stage.

The ratio of phosphoric acid to lime shows a decline in the stem and leaf, and with the exception of Record, in which it remains constant, a rise in the spikelet as maturity advances.

In the leaf the ratio is less than unity at all stages showing the lime to be in excess of phosphoric acid. In the stem when the panicle begins to emerge the phosphoric acid is present in excess of the lime, while at the ripe stage the position is reversed.

The phosphoric acid in the spikelet at all stages is greatly in excess of the lime, illustrating the well-known fact that this portion of the plant is badly balanced in these constituents.

Summary and conclusions.

In four varieties of oats cut at definite physiological and morphological stages of growth, an attempt has been made to investigate the nature and extent of the variations taking place in the mineral and nitrogenous constituents of the whole plants, as well as in their component parts – the stem, leaf and spikelet, respectively.

In the whole plant the percentage of dry matter increases in a fairly steady manner up to the under-ripe stage, after which desiccation is more rapid. The dry matter shows a progressive decrease in its percentage of total ash, potash, lime and chlorine, while its phosphoric acid and lime content remain approximately constant. The fluctuation in the percentage of nitrogen shows a fall to a minimum value at the milky stage, followed by a rise at the under-ripe stage, with a slight falling-off at the ripe stage.

In the leaf there is a rapid decrease in the percentage of total ash, phosphoric acid and nitrogen as the plant matures. On the other hand the percentage of iron appears to slightly increase with maturity.

The stem is characterised by the marked decrease in its phosphoric acid and nitrogen content which takes place continuously from the beginning of the emergence of the panicle to the ripe stage.

In the spikelet the percentage of phosphoric acid and nitrogen remain approximately constant throughout the period, while the potash, lime and chlorine content decrease with maturity.

The migration of dry matter, ash, phosphoric acid, potash, iron and nitrogen from the straw into the spikelet is continuous up to the ripe stage.

The relative proportion of the constituents contained in the leaf falls off progressively as the plant matures. In comparison with other constituents the percentage of the total lime of the whole plant present in the leaf is exceptionally high, while that of the phosphoric acid is low at all stages.

In the stem the relative proportion of constituents present fluctuates in an irregular manner. Thus the dry matter and potash rise to a maximum at the milky stage to fall off in the ripening stages, while the ash and iron remain approximately constant at all stages. Nitrogen and phosphoric acid show a marked falling-off from the panicle fully emerged stage, while the lime and chlorine show a continuous increase with maturity.

The quantitative distribution of chlorine in the oat plant is such that the stem is outstanding in this constituent at all stages, the relative amount present being greatly in excess of that of any other constituent.

In the spikelet the relative proportion of the constituents increases in a fairly regular manner up to the ripe stage, chlorine being exceptional in showing a falling-off in the ripening stages. The proportions of phosphoric acid and nitrogen in the spikelet are outstanding at all stages showing that the migration of these constituents from the straw into the spikelet is much more complete than is the case with the other constituents. Again the percentage of the total chlorine and lime contained in the spikelet is low throughout the period.

The ratio of nitrogen to phosphoric acid in the spikelet remains constant from the beginning of the emergence of the panicle to the ripe stage, while in the straw this ratio decreases with maturity. In the spikelet the ratio nitrogen to lime, and

phosphoric acid to lime increases during the ripening stages, while in the straw there is a marked decrease in these ratios in passing from the beginning of the panicle formation to the milky stage.

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THE CHEMICAL COMPOSITION OF ELEVEN SPECIES AND STRAINS OF GRASSES AT DIFFERENT STAGES OF MATURITY.

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The following investigation on the effect stage of growth has on the chemical composition of a number of grasses was undertaken as a result of earlier work of a similar nature with Italian rye-grass (1).

The previous history of the Cwm Field, which is the property of the Welsh Plant Breeding Station, where the grasses were grown was as follows. Early in 1924 the field received a dressing of basic slag at the rate of 6 cwt. per acre, and in the same year it was used for red clover trials. In 1925 it was ploughed, and in December dressed with lime at the rate of two tons per acre. The field in 1926 lay fallow, and in 1927 previous to sowing the grasses received a further dressing of basic slag at a similar rate to that of 1924.

The eleven species and strains of grasses made use of in the investigation were :—

Perennial rye grass (New Zealand); Perennial rye grass (Commercial); Timothy (Indigenous); Timothy (Commercial); Italian rye grass (Commercial); Meadow Foxtail (Indigenous); Meadow Foxtail (Commercial); Cocksfoot (Indigenous); Cocksfoot (Commercial); Bent; Yorkshire Fog.

These grasses were sown without a nurse crop in 1/100 acre plots, and during the seeding year observations were made on their establishment, rate of growth and palatability (2).

The plots early in August and again in October 1927, were grazed by sheep and then enclosed.

All the samples were cut with shears, the first on April 30, 1928, and represented the growth on three separate square yards of each plot, subsequent samples being taken at approximately monthly intervals from fresh portions of equal area.

After sampling on the 30th of July, the growth on all the plots was cleared, and sampling at monthly intervals again begun on the 1st of September, 1928, and continued up to and including the 30th of March, 1929.

No record of yield of the grasses was taken, but careful botanical notes were kept of the growth made by each grass as well as the condition of the plots generally at the time of each sampling. The investigation naturally falls into two periods. The first represented by the growth made between April and July inclusive, and the second by the growth made between August and March, 1929, inclusive.

If the analysis of the grasses during the first period of the investigation April to July are examined in conjunction with the notes taken at the time of sampling, the interpretation of the results are greatly facilitated. The salient points in these notes covering this period are as follows : All the plots at the first date of sampling apart from that of Yorkshire fog—which contained a number of inflorescence stems—had the typical appearance of early spring growth. The species, however, as would be expected, varied in denseness of growth or in the manner in which they covered the ground. Thus the plots of commercial grasses generally were more patchy than the indigenous and of these varieties the plots of perennial rye-grass and meadow foxtail were the most patchy.

In the interval between the first and second date of sampling, a little rain had fallen but not sufficient to materially affect growth, the weather on the whole during the period being hot and dry. These conditions hastened maturity and as a result the growth became stemmy and several plots had actually reached the hay stage. Among the varieties in the most advanced stage of growth at the second date of sampling were the two perennial rye grasses, commercial cocksfoot, meadow foxtail and Yorkshire fog, though the latter was fairly leafy at the base. The plots of indigenous cocksfoot, meadow foxtail, bent and commercial

timothy in particular contained a high proportion of leaf though the growth on the bent plot was sparse.

In the third sampling those grasses that had not already passed the hay stage were all ripe for cutting as hay. Thus the two perennial rye grasses, commercial cocksfoot, meadow foxtail and Yorkshire fog had passed the hay stage, while Italian rye grass, indigenous cocksfoot, both varieties of timothy and bent were at that stage of growth suited for hay making.

At the fourth sampling, which was the last for the first period of the investigation, the grasses had all passed the hay stage though some such as Italian rye grass, indigenous cocksfoot and meadow foxtail showed a high proportion of leaf to flowering stem.

TABLE I.

Showing the effect of maturity on the percentage of protein, fibre, phosphoric acid and lime in the dry matter of indigenous and commercial cocksfoot.

Date of Cutting.	Cocksfoot (Indigenous)				Cocksfoot (Commercial)			
	Protein	*Fibre.*	*Phosphoric Acid* (P_2O_5)	*Lime* (CaO)	*Protein*	*Fibre*	*Phosphoric Acid* (P_2O_5)	*Lime* (CaO)
April 30, 1928 ..	12.34	21.30	0.917	0.910	13.83	27.67	0.888	0.730
May 29, 1928 ..	11.80	23.05	0.862	0.938	7.46	29.68	0.788	0.833
July 2, 1928 ..	9.12	32.45	0.817	0.992	7.37	32.66	0.690	0.862
July 30, 1928 ..	8.14	33.50	0.805	1.134	5.72	38.00	0.602	0.956

The above two grasses have been chosen because of the striking difference in appearance recorded between the two plots at each date of sampling. The commercial variety, with the exception of the first date of sampling, was always in a more advanced stage of maturity than the indigenous.

The results shown in Table I illustrate the characteristic changes that take place in the composition of grasses with advancing maturity. Thus the percentage of protein steadily falls, the fibre gradually rises, the percentage of phosphoric acid decreases and on the whole the lime increases with age. From the results given in Table IV it will also be seen that the composition of all the grasses are similarly affected with age.

These changes in composition as shown in previous investigations (3) are very largely accounted for by the fact that the proportion of stem to leaf in the produce of a grass gradually increases with age. This increase in the proportion of stem affects the composition of the whole grass roughly as follows. The leaf at all periods is richer in protein and lower in fibre than the stem, any increase therefore in the proportion of stem lowers

the protein and increases the fibre content of the produce. Again the phosphoric acid content of the stem and leaf do not greatly differ, and the percentage in the dry matter of both falls with age. The lime content of the leaf on the other hand is always higher than that of the stem, and while it falls in the latter, it steadily increases in the leaf with age.

From Table I it is seen that the fall in protein and phosphoric acid as well as the rise in fibre content of the commercial variety is much more rapid than in the case of the indigenous variety. This would be expected when it is remembered that at all dates of sampling, apart from the first, the commercial variety was in a more advanced stage of maturity than the indigenous variety.

The significance of these changes to the practical man is first the rapidity with which grass changes into hay, and secondly the deterioration in the composition of hay once it has passed the hay-making stage. These facts have on previous occasions been stressed, but many of our farmers continue to sacrifice quality for bulk both in grass and in hay.

The composition of the other grasses during this period of the investigation exhibit all the characteristics to which attention has been drawn in the case of the cocksfoot in Table I. Thus in the grasses shown in Table IV, which may be taken as representative of all, there is with advancing maturity a steady fall in protein and phosphoric acid accompanied by an increase in fibre content and in the majority of grasses an increase in lime.

As already mentioned the grasses at the second date of sampling were ripe for hay, and at the third date of sampling the growth had gone considerably beyond that stage. The effect of this delay in cutting is accompanied by a deterioration in the composition of the grasses which is readily seen when a comparison is made of the composition of the grasses at the second and third date of sampling. The fourth sample which was taken at a still later date (30th July) further emphasizes this fact, and it is well to note that the composition of the grasses as shown in the fourth sample represents to a very large extent the quality of the hay harvested in Wales.

All the plots on August 2 were cut and cleared of herbage so that the sample taken on September 1 represents the growth between these two dates and may be taken as the aftermath of the different grasses.

When the first sample was taken on September 1 the plots were all in a leafy condition, those of the indigenous varieties generally being more leafy than the commercial. The Yorkshire

fog plot at this time of sampling had a short dense growth of leaf and the bent plot was almost as good.

When sampled on October 2, the best plot was indigenous cocksfoot in spite of the appearance of a small amount of "burn". This plot formed a striking contrast to that of the commercial variety on which the " burn " was very marked. Indigenous meadow foxtail was another plot that looked extremely well, having a quantity of fine long green leaves a few of which, however, were showing a tinge of yellowing. At this time the poorest plot of all was commercial meadow foxtail, the herbage being scanty, patchy and burnt. The Yorkshire fog plot kept its green colour but did not carry much keep and the bent plot had a quantity of short dense growth with no " burn ".

On October 31 at the third date of sampling over 70 per cent. of the plots showed traces of "burn," the commercial varieties of cocksfoot, timothy and meadow foxtail being most affected. At each date of sampling in the second period of the investigation New Zealand perennial rye grass, compared with the commercial plot, has shown up extremely well. This plot kept green, and carried a good bulk of growth consisting almost entirely of leaf which so far had shown no trace of " burn." The commercial variety on the other hand though the growth was mainly leaf, was weedy,shorter and much less bulky. The herbage on the Italian rye grass plot was also very good, it had a fine green colour with no trace of " burn," and in spite of a few scattered flowering stems would at this period have proved most palatable to stock.

Indigenous compared with commercial varieties have throughout shown more keep and herbage of a superior quality. In this connection a comparison of the two meadow foxtail plots at this date of sampling (October 31) is of interest. The indigenous showed considerably more bulk, very little " burn " and the growth was entirely leaf, the commercial plot, however, was thin and although mainly leaf it was very badly burnt.

The Yorkshire fog and bent plots still looked well, the former being slightly superior in appearance owing to the leaf of the bent showing some "burn."

In November the growth on all the plots was small, the two grasses that showed any appreciable growth being New Zealand perennial and Italian rye grass. The " burn " on the remainder of the grasses had greatly increased during the month, the commercial cocksfoot, the two timothy and the meadow foxtail plots being so badly affected that they had become exceedingly brown

and unpalatable to stock. It should be noted that the Yorkshire fog and bent plots had made no growth since the last date of sampling but the fog plot still retained its green colour whereas an incredible increase in " burn " had taken place on the bent plot.

The best plots at this period (November 30) were those of New Zealand perennial and Italian rye grass, both of which were carrying valuable keep for this time of the year.

If the results shown in Table II are studied in conjunction with the foregoing notes taken at the time of sampling their interpretation is somewhat simplified.

TABLE II.

Showing the effect of maturity on the percentage of protein, fibre, ash, and silica in the dry matter of indigenous and commercial meadow foxtail together with Yorkshire fog and bent.

Date of Cutting.	Meadow Foxtail (Indigenous).				Meadow Foxtail (Commercial)			
	Protein.	*Fibre.*	*Ash.*	*Silica (SiO_2)*	*Protein.*	*Fibre.*	*Ash.*	*Silica (SiO_2).*
Sept. 3, 1928 ..	14.95	26.31	10.03	4.01	13.71	24.45	10.62	4.68
Oct. 2, 1928 ..	13.02	26.93	10.49	5.18	11.20	27.01	11.74	6.12
Oct. 31, 1928 ..	12.38	27.24	10.76	5.22	11.16	28.53	12.89	6.79
Nov. 30, 1928 ..	11.81	28.50	11.51	6.00	10.62	29.84	13.26	7.08
	Yorkshire Fog.				Bent.			
Sept. 3, 1928 ..	12.91	25.06	10.65	4.62	14.64	25.13	9.20	4.38
Oct. 2, 1928 ..	12.34	26.37	12.00	4.77	12.21	25.20	10.68	5.11
Oct. 31, 1928 ..	11.77	27.62	12.08	5.40	11.68	26.55	12.55	6.25
Nov. 30, 1928 ..	10.28	28.92	12.33	5.61	9.80	30.77	14.82	8.87

From the aftermath stage onwards, the percentage of protein and fibre is seen to vary in a similar manner to that of a grass passing from the pasture to the hay stage, that is, the protein falls and fibre rises. A comparison of Tables I and II, however, shows this change to take place much more rapidly in the case of a grass passing from the pasture to the hay stage. The change in the composition of the grasses during the period August to November inclusive, is only partly accounted for in this way, because in most seasons after October there is very little, if any, growth.

At this season of the year it will have been noticed that most grasses develop a burnt appearance due to the browning of the leaves, which is known to have a very considerable influence on the composition of the produce (1). Thus an increase of " burn " lowers the protein and increases the fibre ash and silica content of the produce.

An examination of the results given in Table II shows that as the season advances, the protein content of the grasses falls, while their fibre, ash and silica content rises. The bent plot on October 31, as previously stated, was looking well, but when sampled a month later on November 30 it was exceedingly brown. It is therefore of interest to compare the protein, fibre, ash and silica content of the dry matter of this grass at these two dates, and reference to Table II shows that the sample taken on November 30 contains a lower percentage of protein and a higher percentage of fibre, ash and silica. The influence of "burn" is similarly seen on comparing the composition of indigenous and commercial meadow foxtail.

Judged by the appearance of those portions of the plots last sampled (Nov. 30, 1928), the only grasses that had in the interval (Jan. 3, 1929), made any growth were the perennial rye grasses, Italian rye grass, indigenous cocksfoot and Yorkshire fog, the remainder being all badly burnt and in the foggage stage.

Of the perennial rye grasses, New Zealand perennial was the best and at this time would provide an excellent bite for stock. The commercial variety in comparison was patchy. The grass on the Italian rye grass plot for the time of the year was bulky and furnished valuable food, though in the withered leaf tips it bore unmistakable evidence of hard frosts. The Yorkshire fog plot was covered with a short dense herbage and had an excellent appearance. The growth between January 3 and February 4 was negligible, and the Italian rye grass plot showed still further signs of the frost, a high proportion of the leaves having completely died back though a few green leaves were still showing. The uncut herbage was still green and palatable on both the New Zealand perennial rye grass plot and the commercial variety plot. The latter, however, had never compared with the former either in bulk or freedom from weeds. The Yorkshire fog plot had at this period a yellowish green colour and had fallen in value very considerably since the last date of sampling. It is evident that in order to obtain the best value from the Italian rye grass and Yorkshire fog plots they should be grazed before Christmas.

A succession of snow storms and continued hard frosts made the weather conditions during February very severe with the result that none of the plots showed any growth.

When the plots were examined on March 2 they were found to be severely burnt and of little value for grazing. The weather from the last date of sampling up to the 20th of March was dry, but prior to the date when the last samples of

the series were taken (March 30), there had been two days of light rain followed by warm dry weather. This rain though small in amount made a great difference in the appearance of some of the plots, their colour in a surprisingly short time being changed from brown to a fresh green. Among the plots showing the greatest amount of green at this period were the two perennial rye grasses and indigenous and commercial timothy. The plots of the two cocksfoots, meadow foxtails, Italian rye grass, fog and bent were still predominantly brown though on close examination a few green leaves were to be seen on all plots.

Table III shows the change in composition of four grasses during December and the first three months of the following year. These particular grasses have been chosen for the reason that throughout the period with the exception of February the perennial rye grasses have shown a fair proportion of green, while both indigenous and commercial timothy until the month of March were more or less at a standstill. In this month, however, the growth of both grasses made a striking change in the appearance of the plots.

TABLE III.

Showing the percentage of protein, fibre, phosphoric acid and lime in the dry matter of four grasses left uncut from August 2, 1928, until the dates indicated.

Date of Cutting.	Perennial Rye Grass (New Zealand)				Perennial Rye Grass (Commercial).			
	Protein.	*Fibre.*	*Phosphoric Acid* (P_2O_5)	*Lime* (*CaO*)	*Protein.*	*Fibre.*	*Phosphoric Acid* (P_2O_5)	*Lime* (*CaO*).
Jan. 3, 1929 ..	14.64	24.07	0.900	0.742	16.38	24.42	0.920	0.756
Feb 4, 1929 ..	14.50	25.33	0.817	0.742	16.19	23.01	0.928	0.770
Mar. 2, 1929 ..	13.95	25.21	0.710	0.762	14.04	25.62	0.804	0.679
Mar. 30, 1929 .	16.88	22.98	0.840	0.987	16.89	22.26	0.888	0.980
	Timothy (Indigenous).				Timothy (Commercial).			
Jan. 3, 1929 ..	9.98	28.13	0.578	0.756	9.01	27.42	0.427	0.742
Feb 4, 1929 ..	11.77	28.62	0.587	0.742	9.50	26.88	0.437	0.714
Mar 2, 1929 ..	10.21	27.56	0.646	0.637	9.84	26.29	0.537	0.672
Mar 30, 1929 .	12.34	26.19	0.705	0.826	14.70	24.31	0.721	0.882

In Table III the results show that the two perennial rye grasses, judged by their chemical composition, give keep of very good quality during what might be termed the dead season of the year. In comparing these two grasses it has to be remembered that the New Zealand variety supplied much more bulk than the commercial and in consequence the plot was more free from weeds. It should be emphasised that in all the results it

is the composition of the grasses that are given and that no weeds are included.

As already mentioned, the amount of growth during the months of December, January and February was very small and at the end of February the herbage on all the plots was badly burnt. However, in March some fresh growth had taken place, and its influence on the composition of the produce on March 30 as compared with that of March 2 is readily seen. In all the grasses there is an increase in protein and a fall in the fibre content of the sample taken on March 30 compared with that of March 2. The phosphoric acid and lime content were similarly affected.

In Table IV, the composition of two of the grasses cut at different stages of maturity from April to March are given. It should be borne in mind, however, that the plots in August were

TABLE IV.

Showing the composition of Italian rye grass and Yorkshire fog at different stages of growth in passing from the pasture to the hay stage, and from the aftermath stage to the end of March.

Date of Cutting.	Crude Protein.	True Protein.	Fibre.	Ash	Silica-free Ash.	Phosphoric Acid (P_2O_5).	Lime (CaO).
	Italian Rye Grass.						
April 30, 1928	10.67	7.26	20.65	10.30	6.85	1.023	0.966
May 29, 1928	10.01	8.53	21.54	8.30	6.48	0.834	1.050
July 2, 1928	7.80	6.72	32.50	7.65	4.75	0.731	0.986
July 30, 1928	7.52	7.04	36.55	5.13	2.99	0.684	1.110
Sept. 1, 1928	17.50	16.00	25.00	13.38	10.25	1.238	1.639
Oct. 2, 1928	16.98	14.70	25.33	13.05	10.08	1.352	1.422
Oct. 31, 1928	16.23	15.22	27.87	12.72	9.27	1.120	0.934
Nov. 30, 1928	15.71	15.14	28.31	13.24	7.82	0.918	0.966
Jan. 3, 1929	14.88	14.11	27.92	11.51	5.82	1.008	1.040
Feb. 4, 1929	14.02	13.87	27.66	11.89	5.13	0.930	0.940
Mar. 2, 1929	13.76	12.65	29.91	12.62	4.19	0.942	0.942
Mar. 30, 1929	15.55	13.85	28.07	14.59	8.51	1.040	1.009
	Yorkshire Fog.						
April 30, 1928	13.49	10.76	22.94	10.10	6.39	0.700	0.639
May 29, 1928	9.08	8.63	29.35	9.26	5.29	0.616	0.601
July 2, 1928	5.38	5.25	32.70	8.14	4.58	0.560	0.511
July 30, 1928	4.55	4.46	34.61	7.26	3.92	0.580	0.492
Sept. 1, 1928	12.91	11.33	25.06	10.65	7.23	1.190	1.230
Oct. 2, 1928	12.34	11.33	26.37	12.00	6.68	1.020	1.134
Oct. 31, 1928	11.77	10.76	27.62	12.08	6.72	0.986	0.966
Nov. 30, 1928	10.28	9.85	28.92	12.33	6.03	0.934	1.009
Jan. 3, 1929	9.62	9.06	28.20	12.11	5.33	0.809	0.822
Feb. 4, 1929	10.04	9.32	28.39	11.30	4.23	0.784	0.742
Mar. 2, 1929	9.12	8.74	29.01	11.26	3.70	0.730	0.702
Mar. 30, 1929	11.22	9.68	24.15	12.54	5.70	0.744	0.896

cleared of all growth, and that the cuts taken subsequent to this date show the composition of the grasses at different stages of maturity from August onwards.

General conclusions.

Attention is drawn in the paper to the rapidity with which grass changes from pasture to the hay stage of growth, and the deterioration in composition of hay once it has passed the hay making stage. These facts do not appear to be as fully realised by our farmers as they ought to be, for many continue to sacrifice the quality of both grass and hay for bulk.

The indigenous strains of grasses are later in maturing to the hay stage than the commercial, and in consequence may be cut a little later for hay.

The superiority of the rye grasses and in particular the perennial in remaining winter green is emphasized, these grasses giving nutritious and palatable herbage at a time when most of the other grasses were either burnt or giving very little " keep."

As it is the practice of some farmers to keep fields " in foggage " for autumn and winter grazing, it is important to realize that the nutritive value of such foggage deteriorates as the winter advances.

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THE CHEMICAL COMPOSITION OF PASTURE GRASS UNDER DIFFERENT SYSTEMS OF MANAGEMENT.

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The forecasting of fundamental changes in grassland management by eminent agriculturalists to-day, must apply more particularly to Wales than any other country in the British Isles, since firstly, the Principality is mainly devoted to stock raising, and secondly the relief of this country is such that the quality of the herbage in the main is of a poorer type. Wales, therefore, being essentially a pastoral country, emphasis has rightly been laid on increasing the stock raising capacity of our pastures.

That Welsh pastures vary considerably in quality has been clearly shown by Fagan (1), who divides them into the following four grades :—

1. Second-rate pastures;
2. Third-rate pastures;
3. Fescue pastures;
4. Nardus pastures.

While fully realising that these differences are due chiefly to botanical characteristics, and that the improvement of such pastures must be achieved by methods which aim at changing the flora, it should be remembered that considerable improvements can be effected by judicious grazing.

Thus, Woodman (2) has shown that pasture grass kept short by close grazing contains a very high percentage of protein throughout the season, and that further this richness in respect of protein is to a large extent independent of the botanical character of the herbage, or the presence of much or little wild white clover in the pastures. Again judicious grazing itself improves the botanical character of the herbage by encouraging the spread of wild white clover in the pastures. Indeed this method of increasing the percentage of this highly nutritious pasture plant almost rivals the well known method of slagging *providing the grazing is not too severe.*

The practical man, however, naturally and rightly takes the stock carrying capacity of his pasture as the best criterion of its value, but unfortunately, he too frequently bases his calculations more on the quantity that the quality of the keep. Rotational grazing undoubtedly results in greater stock carrying capacity, but with the spread of this new system of grassland management many difficult problems confront the farmer.

Thus how long should a pasture be rested between successive grazings to obtain the maximum amount of nutrients per acre, and under such a system of management, are the nutrients balanced to meet the requirements of the stock?

Fagan, Milton and Provan (3) have shown that grasses and clovers have a much higher nutritive value when cut weekly than when cut monthly, but the actual amounts of nutrients per acre at the disposal of the animal are much greater under the latter system than the former. Woodman (4), however, has clearly demonstrated that pasture grass cut at monthly intervals is not nearly so digestible as that submitted to a more intense system of grazing, while Fagan (5) rightly points out that much of the extra keep available under the more lenient system of cutting, is rendered valueless by the trampling and manuring of

the animals. Thus the last writer states that the best system lies somewhere between these two extremes, exactly where, the farmer having to decide for himself. Further information on this important question seemed desirable, and to obtain the necessary data the following investigation was undertaken.

An experimental area of 1.8 acres was marked out and this divided lengthways into three equal traverses, each traverse being subsequently divided into five plots. Each plot was 0.12 acres, making each traverse 5 × 0.12 = 0.6 acres and the whole experimental area 3 × 0.6 = 1.8 acres.

A plan of the experimental area is shown below in Diagram I.

DIAGRAM 1.

Experimental area.

Top traverse.	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.
Middle traverse.	,, 1.	,, 2.	,, 3.	,, 4.	,, 5.
Bottom traverse.	,, 1.	,, 2.	,, 3.	,, 4.	,, 5.

Five Kerry Hill lambs were employed to graze each traverse, and the rotation arranged so that the rest periods between two consecutive grazings were as follows :—

Traverse.	Rest Period.
Top.	Month.
Middle.	Fortnight.
Bottom.	Four days.

When the investigation was commenced on the 18th of May, 1928, the lambs had been weaned for a fortnight and varied from twelve to sixteen weeks in age. The average weight of each lot of five lambs at the commencement of the experiment was 58 lb. The lambs were weighed at weekly intervals throughout the investigation, every precaution being taken to overcome variations in live weight by weighing the lambs at the same hour of the day each week. Weighing was carried out on the plots by

means of a Steelyard balance supported on a tripod, each lamb being supported by a double body-band.

It was found that this stocking was insufficient to consume all the keep available, and to ensure that each plot had its full rest period, it was necessary to clear the extra fodder in one day. To accomplish this, additional sheep were introduced, sufficient in number to graze the plots bare in one day, and consisted mostly of two-three year old breeding ewes, each of which was reckoned to be equivalent to two lambs.

Valuable data were obtained on the carrying capacity of pastures and the live weight increase of lambs as affected by management, and have already been published (6). The present paper will therefore be confined to the effect of the grazing animal on the chemical composition of pasture grass under the three systems of management.

Method of sampling.

The plots were sampled with a one-foot mesh and to ensure that the sample was representative, ten such areas were cut and the whole produce thoroughly mixed. When sampling the various traverses the mesh was thrown at random into the plots, care being taken, however, to avoid the areas near the boundaries, because of the tendency of sheep to lie down near the fences, especially during hot weather.

1. Top Traverse.

Before the sheep entered Plot I a representative sample of the herbage was taken in the manner described above. The lambs then grazed the plot for a week after which the herbage was again sampled. The following week the lambs were moved on to Plot II; representative samples of the herbage on this plot being again taken at the commencement and end of the grazing period. At the end of the second week the lambs were moved on to Plot III, and at the end of the third week on to Plot IV, &c., samples of the herbage from each plot being taken weekly immediately before and after grazing.

2. Middle Traverse.

Here again Plot I was sampled before the lambs commenced grazing the herbage and again at the end of three or four days, which was the length of the grazing period allowed on the plots of this traverse. The lambs were then turned into Plot II, and the herbage of this plot was sampled before they commenced grazing and after three or four days. The two samples taken from Plots I and II before grazing—representing a week's growth

—were then pooled as also were the two samples taken after grazing.

3. Bottom Traverse.

The lambs on this traverse were moved from one plot to another daily and therefore grazed seven plots every week. Each of these plots was sampled before and after grazing; the seven samples taken every week before grazing being pooled, as also were the seven samples taken after grazing.

It will therefore be seen that six samples were analysed each week : one from each traverse before and after grazing. The experiment was continued for 25 weeks, so that the total samples analysed numbered 150 (25 × 6).

The chemical composition of the samples.

The analytical data have been averaged into periods of five weeks to emphasize the difference in chemical composition of the herbage resulting from variation in the rest period.

Table I gives the crude protein, crude fibre and ether extract content of the herbage from each traverse before and after grazing for each period.

From this Table it is seen that under the three systems of grazing a fairly high protein content is maintained in the herbage throughout the season, there being no characteristic decrease such as is found in grass allowed to grow unchecked for a considerable interval of time.

The maximum protein content occurred during the fourth period, and it is worthy of note from the record of observations kept, that at this time the sheep scoured. This fact, together with the observation that scouring appeared first among the animals on the traverse which contained the highest percentage of protein, tends to support the general belief that a ration too rich in this constituent causes animals to be affected in this way.

On comparing the protein content of the herbage from each traverse before grazing, it is clearly seen that this is highest under the most intense, and lowest under the most lenient system of grazing, which is in keeping with the work of Fagan (5) on individual grasses and Woodman (4) on pastures, who have shown that frequent cutting increases the nutritive value of herbage plants.

Another interesting feature of Table I is that throughout the season the herbage on each traverse is lower in crude protein after grazing than before, which seems to indicate that the lambs showed a certain selectiveness in their grazing, choosing young

TABLE I.

Showing the percentage of Crude Protein, Crude Fibre, and Ether Extract in the dry matter of the samples from each traverse before and after grazing.

	(Month Rest Period) Top Traverse.					(Fortnight Rest Period) Middle Traverse.					(Four Day Rest Period) Bottom Traverse.				
Period.	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Percentage Crude Protein Before Grazing	12.03	15.98	17.96	21.01	17.24	12.60	16.38	18.54	21.09	18.11	12.90	17.06	19.00	23.02	18.56
Percentage Crude Protein After Grazing	9.86	14.25	16.84	19.21	16.43	11.52	15.63	16.86	20.95	16.60	11.47	15.53	18.88	20.85	18.12
Percentage Crude Fibre Before Grazing	28.65	31.55	29.21	27.55	25.25	27.26	29.45	27.89	25.39	26.32	25.82	30.42	26.95	25.92	26.60
Percentage Crude Fibre After Grazing	30.73	32.79	30.36	28.59	26.68	28.16	30.01	27.53	26.00	25.95	27.85	30.65	26.59	26.36	26.44
Percentage Ether Extract Before Grazing	3.61	2.26	3.39	3.37	2.79	3.50	2.27	3.17	3.55	3.14	3.38	2.29	3.15	3.19	2.93
Percentage Ether Extract After Grazing	3.71	2.27	3.16	3.06	2.71	3.58	2.02	3.05	3.27	3.24	3.41	2.21	3.09	3.43	2.82

succulent blades in preference to older less nutritious stems. That sheep exhibit a marked degree of selection in grazing is, however, no new idea. The work of Stapledon and Jones (7) clearly demonstrates this, and the present results support the conclusion.

The percentage of crude fibre in pasture grass although not necessarily a criterion of its nutritive value, does give some indication as to the general character of the herbage when submitted to different systems of grazing. Thus, reference to Table I shows that the herbage on the top traverse, which was the most leniently grazed, is definitely higher in this constituent than the herbage from the other two traverses. This is only to be expected, since the young succulent herbage such as is produced by frequent grazing contains a lower percentage of this constituent than older, more mature growth. The difference in the crude fibre content of the herbage from the middle and bottom traverses is small, so that under the conditions of this investigation, a rest period of less than a fortnight did not materially lower the percentage of this constituent in the herbage.

It is worthy of note that the maximum crude fibre content of the herbage from each traverse was exhibited during the second period. This is readily accounted for, since the second period (June) corresponds to the time of the year when all pastures tend to produce panicle despite frequent grazing. It will be seen from Table I that during this period the bottom traverse is higher in crude fibre than the middle, notwithstanding the fact that the former was subjected to a very intense system of grazing. Thus, no matter how heavily a pasture is grazed, the herbage will become stemmy during June, and as Fagan (5) points out, running a mower over the majority of our pastures during this period might prove profitable.

Table I shows further that under the most lenient system of management the herbage is higher in crude fibre after grazing than before. This is quite in keeping with the previous findings, because the stems of plants are higher in this constituent than the leaves, and since the plots were grazed selectively, the herbage would naturally be more stemmy at the end than the commencement of each grazing period. The same general tendency can be seen in the herbage from the other traverses, but under these more intense systems of management the differences are not so pronounced. This, of course, is only to be expected because under systems of management which allow only short rest periods between successive grazings, the amount of keep

available is smaller, and hence the degree of selection exercised in grazing is not so marked.

The ether extract content of the herbage is but little affected by the different systems of grazing. Reference to Table I shows, however, that under each system of management, the minimum percentage of this constituent in the herbage was exhibited during the second period (June). This is probably due to the fact that the ratio of stem to leaf is high at this time of the year, and the fact that this period corresponds to that of the maximum crude fibre content tends to support this explanation.

The high ether extract content of all the samples in the first period (May) can be similarly accounted for, because the first spring flush is naturally very leafy and would therefore be rich in chlorophyll.

The mineral content of the samples.

The winter rations of cattle in Wales are often unbalanced in respect of their mineral requirements, with the result that dairy cattle, for example, often have to draw on the minerals in their bodies to maintain the supply in the milk, especially if they are heavy yielders (8). The effect of this strain on the animal body is often evident in the low condition of vitality and resistance to disease exhibited by such animals when they go out to grass in spring. To overcome these ill effects of winter malnutrition, the animal is largely dependent upon young grass, so that the mineral content of pastures under varying systems of management becomes a matter of considerable importance.

The mineral content of pasture grass under intense systems of management is also of importance in connection with sheep grazing, since Fagan (1) has shown that the stunted growth of highland sheep can probably be attributed to the low lime and phosphate content of the herbage growing at such high altitudes.

Table II gives the percentage of silica-free ash, lime and phosphoric acid in the dry matter of the herbage of each traverse before and after grazing for every period.

From this table it is seen that the percentage of silica-free ash in the dry matter of the herbage from the top and middle traverses, increases until the third period, falls slightly in the fourth to rise again in the last period.

It is worthy of note, however, that the silica-free ash content of the herbage from the most intensely grazed traverse shows no such decrease. Here, the percentage of this constituent rises steadily throughout the season reaching a maximum in the last period. Even under the "monthly" and

"fortnightly" rested systems the decrease during the fourth period is slight, so generally it may be said that under the three systems of management a fairly high percentage of this constituent is maintained in the herbage throughout the season.

Again, under the three systems the silica-free ash content of the herbage is lower after grazing than before, the difference being less pronounced as the intensity of grazing increased. This is further evidence that sheep are selective in their grazing, the degree of selection exercised being mainly determined by the amount of keep available.

Table II shows that the lime content of the herbage from each traverse reaches a maximum in the third period (July) which is in agreement with the work of Woodman (9). That a maximum lime content is shown to occur at this period is probably due to the fact that certain clovers (10)—particularly wild white—reach their zenith of growth in July, since it has been repeatedly shown by work carried out at Aberystwyth that clovers are vastly superior to grasses in this constituent. Further, Fagan and Jones (11) have shown that the leaves of grasses are richer in lime than the stems, and in the same paper demonstrate that the proportion of leaf to stem is highest during the period corresponding to the aftermath. These factors would therefore necessarily tend to increase the lime content of the herbage during this time of the year.

On comparing the lime content of the herbage under the three systems, reference to Table II shows that during the first two periods, this is highest on the more intensely grazed traverses, being probably accounted for by an increase in the ratio of leaf to stem which accompanies intensive grazing. Wild white clover does not make a significant contribution to the herbage during this time of the year, so that the higher lime content of the herbage on the bottom traverse can hardly be attributed to a higher percentage of this valuable pasture plant. During the third and fourth periods, however, the highest lime content is found in the herbage from the middle traverse, and since at this time of the year the amount of clover in pastures is appreciable, the differences in the lime content of the herbage under the three systems can probably be correlated with the percentage of clover in the herbage. Thus on the bottom traverse the development of wild white clover was probably prevented by the extreme intensity of grazing, while on the top traverse, the grazing was sufficiently lenient to permit a certain amount of shading out by the grasses. On the middle traverse, however, where the lime content of the herbage was highest

TABLE II.

Showing the Silica-free-ash, Lime and Phosphoric Acid content of the herbage from each traverse before and after grazing during each period.

	(Month Rest Period) Top Traverse.					(Fortnight Rest Period) Middle Traverse.					(Four Day Rest Period) Bottom Traverse.				
Period.	1	2	3	3	5	1	2	3	4	5	1	2	3	4	5
Percentage Silica-free-ash Before Grazing	5.85	8.03	9.28	8.75	9.41	5.98	7.17	9.20	8.61	9.05	6.05	7.14	7.99	8.23	8.44
Percentage Silica-free-ash After Grazing	5.35	7.05	8.25	8.03	8.18	5.86	7.10	8.35	8.11	8.33	5.87	7.03	8.28	7.87	8.04
Percentage Lime Before Grazing (CaO)	0.950	1.279	1.454	1.101	0.945	1.104	1.313	1.526	1.191	0.930	1.142	1.343	1.389	1.020	0.858
Percentage Lime After Grazing (CaO)	0.865	1.144	1.365	1.005	0.837	1.092	1.243	1.483	1.064	0.909	1.085	1.326	1.422	1.060	0.818
Percentage Phosphoric Acid Before Grazing (P_2O_5)	0.565	0.612	0.784	0.839	0.893	0.635	0.705	0.840	0.948	1.000	0.609	0.713	0.847	0.943	0.965
Percentage Phosphoric Acid After Grazing (P_2O_5)	0.523	0.539	0.741	0.761	0.859	0.613	0.647	0.837	0.913	1.000	0.631	0.729	0.835	0.888	0.914

during this period, the system of grazing was probably not sufficiently intense to prevent development of white clover, while, on the other hand, it was not sufficiently lenient to permit shading out and smothering.

A comparison of the lime content of the samples before and after grazing again points to the conclusion that sheep are selective in their grazing, the degree of selection being greater when keep is plentiful than when it is scarce.

Table II brings out one important difference in the seasonal variation of the phosphoric acid and lime content of the herbage under the three systems of management. Thus, whereas the lime reaches a pronounced maximum during the third period and then falls off, the phosphoric acid shows a steady rise throughout the season.

In view of the fact that young stock should receive rations well balanced as regards their mineral content, this difference is important, and its significance in connection with rotational grazing is worthy of greater attention.

Table II shows further that of the three systems under review the herbage which was allowed a month's rest between two successive grazings is definitely lower in phosphoric acid than that from the other traverses. There, is, however, no significant difference in the phosphoric acid content of the herbage from the middle and bottom traverses. Thus under the conditions of this investigation a more intense system of grazing than one which allows a fortnight's rest between two successive grazings, has no beneficial effect as regards this constituent of the herbage

The nutritive ratio of the herbage under the three systems.

In rationing for production, whether it be fat lamb, beef or milk, one is concerned not only with the quantity but with the balance of nutrients. With the spread of the practice of rotational grazing and the consequent increase in the protein content of the herbage, the possibility that such food might be unbalanced cannot be ignored. Table III, which gives the nutritive ratio of the herbage from each traverse, shows that this is not appreciably affected by the three systems of grazing, although the tendency is for it to become narrower as the intensity of grazing increases

Under each system, however, the nutritive ratio becomes considerably narrower as the season advances. This is contrary to the requirements of fattening animals, since they should be fed with a ration of narrow nutritive ratio in the early period

of growth, becoming gradually wider towards the end of the fattening period. This indicates that under the three systems, foods rich in carbohydrates should be fed towards the end of

TABLE III.

Showing the nutritive ratio of the herbage from each traverse for the first three periods.

Traverse.	*Period 1.*	*Period 2.*	*Period 3.*
Top traverse. (Month Rest period).	1 : 7.12	1 : 4.84	1 : 4.20
Middle traverse. (Fortnight Rest period).	1 : 6.75	1 : 4.67	1 : 3.99
Bottom traverse. (Four Day Rest period).	1 : 6.52	1 : 4.43	1 : 3.88

the fattening period, and suggests that the rapid falling-off in live weight increase of lambs observed by Phillips (12) may be due partly to the narrow nutritive ratio of their food during this period.

Summary.

An account is given of the effect of varying the rest period on the chemical composition of pasture grass.

It was found that the protein content of the herbage increased with the intensity of grazing. The percentage of crude fibre, on the other hand, was greatest in the herbage which was subjected to the most lenient system of grazing. Under the three systems a high protein and low fibre content is maintained in the herbage throughout the season. The lime and phosphoric acid content of the herbage was also lowest under the most lenient system. While, however, the lime content of the herbage under the three systems exhibits a pronounced maximum during the third period (July) the phosphoric acid rises steadily throughout the season.

The herbage under the three systems was poorer in chemical composition after grazing than before, which suggests that the lambs were selective in their grazing. The results also indicate that under the conditions of this experiment, the degree of selection exercised is probably determined by the amount of keep available to the grazing animals.

The nutritive ratio of the herbage under the three systems of management does not differ greatly, although the tendency is for this to become narrower as the intensity of grazing increases.

Under all three systems it is clearly shown that the nutritive ratio of the herbage is much narrower at the end than the beginning of the season. This is contrary to the requirements of fattening animals and the advisability of feeding carbohydrate concentrates towards the end of the fattening period is emphasized.

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THE RECOVERY OF NITROGEN IN PASTURES FROM THE APPLICATION OF NITROGENOUS MANURES.

PART II.

THE RECOVERY OF NITROGEN IN ORDINARY SWARDS.

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In the previous volume of this Journal (1) the recovery of nitrogen from pure species of pasture and clover was dealt with. The main conclusions arrived at were that a very high return of nitrogen was possible from the different species of grasses, but that red clover was indifferent to the action of the manures. In the present article it is proposed to consider the recovery of nitrogen which has been obtained under radically different conditions from those already described. This has been rendered possible as the findings of two years' work carried out by the Welsh Plant Breeding Station on the application of nitrogen to small plots of grassland at different elevations are now available. The significance of these experiments has already been dealt with from a number of standpoints (2), and in the present article we shall confine attention to the recovery of manurial ingredients derived from the different types of pasture. It should be pointed out that the plots were four square yards in area, three plots being treated at each centre in the following way.

Plot 1. Control—no manure.

Plot 2. Phosphate as superphosphate (16 per cent. P_2O_5) applied at the rate of 2 cwt. per acre per annum, and potash as kainit (20 per cent. K_2O) in one application of 4 cwt.

Plot 3. As in plot (2) with the addition of soluble nitrogen at periods of about one month to equal approximately 100lb. nitrogen per annum. This was applied in 1927 partly as sulphate of ammonia and partly as nitrate of soda, and in 1928 wholly as nitro chalk.

Owing to the small area of the plots, significance can only be placed on those oustanding features which are revealed by a consideration of all the results so far obtained from the different

centres. During the growing season the produce was cut at monthly intervals, the winter growth from November 1 onwards being cut on May 1. From the weight and analysis of the dry matter from each cut, the total nitrogen derived from the different plots at each centre for the whole year has been calculated. The increased yield of nitrogen in lb. per acre due to the application of 100lb. soluble nitrogen has been obtained by subtracting the total yield per acre per annum in Plot 2 from that in Plot 8. Five lowland centres have been dealt with in this way during 1927, and four during 1928. The maximum and minimum recovery of nitrogen obtained over each of the two seasons is indicated in Table I. Similarly the mean recovery obtained by the inclusion of all the centres is shown for each season. The results for three upland centres are set out in the same manner.

TABLE I.

Showing the recovery of Nitrogen in lb. per acre from lowland and upland swards during 1927–8 and 1928–9.

Season.	*Plots.*	*Nitrogen applied per acre (lb.).*	*Nitrogen recovered per acre (lb.).*		
			Max.	*Min.*	*Mean.*
1927-8	Lowland	100	59.0	0.0	35.6
1927-8	Upland	100	49.0	38.0	43.7
1928-9	Lowland	100	51.0	0.0	21.0
1928-9	Upland	100	129.0	27.0	80.0

From the above Table it is evident that the amount of nitrogen which can be recovered from both lowland and upland swards is exceedingly variable. In spite of these variations, however, it is seen that in 1928-29, when the nitrogen was applied as nitro chalk, the recovery from the upland plots was of a much higher order than from the lowland plots. The two questions of importance which therefore arise from a consideration of Table 1 are :

1. What are the reasons underlying the extreme variations in the recovery of nitrogen from these different plots?
2. Why should a greater recovery be possible from the upland swards, which owing to soil and climate naturally yielded much less herbage than the lowlands?

First, in connection with the lowland plots, we find there are two factors on which the recovery of nitrogen is intimately dependent. The first of these is the amount of clover in the

sward to which no nitrogen was applied. This is brought out in Table II. The nitrogen yielded by the legumes has been calculated from the dry matter weight of wild white clover in the swards. The composition of this clover was taken at each centre as 4.56 per cent. nitrogen for the no nitrogen plot, and 4.46 per cent. for the nitrogen plot, figures obtained from the analyses of a series of wild white clover samples cut at monthly intervals during 1928 on control and nitrogen plots (3).

TABLE II.

Showing the loss of Nitrogen in lb. per acre from lowland swards as a result of decrease in legume yield following the application of Nitrogenous manure—mean yearly results.

	Yield of legumes.		*Estimated yield of Nitrogen in legumes.*		*Estimated diminution in Nitrogen yield due to decrease in legumes.*
Centre.	*No Nitrogen* *lb. dry matter.*	*Nitrogen* *lb. dry matter.*	*No Nitrogen* *lb.*	*Nitrogen* *lb.*	*lb.*
Bank ...	1278	51	58.2	6.7	51.5
Rhoscellan	1174	56	53.5	2.5	51.0
Nantcellan	787	96	25.4	4.3	21.1
Nantsiriol	291	72	13.3	3.3	10.0

From the Table it is clear that the diminution in nitrogen depends on the yield of clover in the plot to which no soluble nitrogenous manure was applied. The greater this yield, the greater will be the amount of nitrogen lost as a result of the depressing action of the nitrogen on the clover. Where the legume yield is considerable in the untreated sward more than 50 per cent. of the nitrogen applied as manure is lost owing to the depression in clover yield. Even when the legume yield is low, the loss due to this factor is still a considerable one. It therefore follows, other things being equal, that the richer a sward is in clover, the lower is the return to be expected from a dressing of nitrogenous manure. Indeed this experiment has shown that in certain swards rich in clover, the nitrogenous manure may effect a diminution in nitrogen yield by depression of the legumes, so as to completely obliterate the increase in nitrogen yield from its effect on the grass. Hence the total absence of any recovery of nitrogen experienced at some lowland centres as shown in Table I.

The second factor on which the recovery of nitrogen depends is the yield of grasses and weeds in the plot to which no soluble nitrogen has been applied. It is found that the higher this yield, other circumstances being similar, the higher the recovery of nitrogen which can be expected. This is shown in Table III, where the average values for the two seasons have been calculated.

TABLE III.

Showing the relationship between the dry matter yield of grasses and weeds in a sward, and the gain in Nitrogen yield following the application of soluble Nitrogenous manure.

Centre.	*Average annual yield of grass and weeds. (lb. dry matter per acre).*		*Estimated yield of Nitrogen in grasses and weeds. (lb. Nitrogen per acre).*		*Average annual gain in Nitrogen due to increase in grasses and weeds.*
	No Nitrogen	*Nitrogen*	*No Nitrogen*	*Nitrogen*	
Rhoscellan	2898	4478	79.2	125.4	46.2
Nantsiriol	3321	5375	91.1	146.0	54.9
Bank ...	3995	5963	108.7	167.3	58.6
Nantcellan	4870	6956	139.1	206.2	67.1

Thus when soluble nitrogenous manures are supplied to the lowland plots we find that there are two factors having a counteracting effect one on the other. On the one hand there is a diminution in nitrogen yield due to the suppression of the clover, while on the other hand there is an increased nitrogen

TABLE IV.

Showing the nett recovery of Nitrogen as a result of applying soluble Nitrogen to lowland swards containing wild white clover.

Centre.	*Clover yield in sward. (lb. dry matter).*	*Diminution in Nitrogen due to decrease in legumes. lb.*	*Increase in Nitrogen due to effect on grasses. lb.*	*Per cent Nitrogen recovery*
Rhoscellan	1174	51.0	46.2	Nil.
Bank ...	1278	51.5	58.6	7.1
Nantcellan	787	21.1	67.1	46.0
Nantsiriol	291	10.1	54.9	44.8

yield in so far as the contribution of the grasses is concerned. The actual nitrogen recovered as a result of the manuring will,

as is shown in Table IV, depend on the relative importance of these factors in the particular sward which has been treated with nitrogen.

The above Table emphasises the importance of the nitrogen contribution of the clover in the sward, and shows that where the yield of clover is large the loss owing to its supression may entirely nullify any gain in the nitrogen contributed to the herbage as a result of manuring with nitrogen. Indeed, the factor on which the recovery of nitrogen mainly depends is the yield of clover in the untreated sward. The wide variations in nitrogen recovery were undoubtedly mainly due, in so far as these lowland swards were concerned, to the great differences between these swards in their clover yield per acre. The fluctuations from one sward to the other in the amount of nitrogen recovered from the grasses are much smaller than those in the amount of nitrogen lost as a result of clover suppression.

While this clover factor tended towards lowering the recovery from the lowland centres, other factors tended to increase the recovery from the upland centres. Here the proportion of moss and burnt herbage was radically reduced as a result of the application of nitrogen and this meant less restriction for the grasses to develop. The intimate bearing of this factor on the recovery of nitrogen is brought out in Table V, where the diminution in moss and burnt herbage per 100 lb. pasture is shown side by side with the nitrogen recovered.

TABLE V.

Showing the relationship between the eradication of moss and burnt herbage and the percentage Nitrogen recovered from upland swards.

Centre.	*1st season (1927).*		*2nd season (1928).*	
	Diminution in moss and burnt herbage per 100 lb. pasture.	*Per cent. Nitrogen recovered.*	*Diminution in moss and burnt herbage per 100 lb. pasture.*	*Per cent. Nitrogen recovered.*
Foel ...	0	38	0.19	27
Pensarn ...	3.40	44	7.11	84
Llety ...	3.30	49	12.69	129

It is seen from the above that the greatest recovery of nitrogen occurred at Pensarn and Llety during the second season when the greatest reduction in moss and burnt herbage was effected. The fact that the eradication of moss and burnt herbage was so much greater during the second season is noteworthy. It is

difficult to see that this can have been a seasonal effect or that it was due to the cutting and treading of the plots, as there was no great variation between the two seasons in so far as the control and PK plots were concerned. Table VI shows that the seasonal effect, if anything, tended towards increasing the proportion of moss in the herbage.

TABLE VI.

Showing the percentage of moss and burnt herbage in control, PK, and PKN plots for each season of treatment.

Centre.	*Control Plot.*		*PK Plot.*		*PKN Plot.*	
	1st year.	*2nd year.*	*1st year.*	*2nd year.*	*1st year.*	*2nd year.*
Foel ...	3.95	7.75	1.50	1.30	1.90	1.11
Pensarn ...	10.80	13.05	6.67	7.84	3.27	0.73
Llety ...	28.90	27.00	12.40	13.96	9.11	1.27
Average ...	14.55	15.93	6.82	7.70	4.76	1.00

It is plainly seen from Table VI that the diminution in moss and burnt herbage during the second year as compared with the first is limited to the nitrogen plots. This effect of eradicating the moss to a greater extent during the second season must therefore be set down to one of two factors. (*a*) The cumulative effect of the nitrogenous manures. It is possible that this may be gradual, and that it does not fully manifest itself until the second season. (*b*) A possible greater effectiveness possessed by nitro-chalk in the elimination of moss compared with other nitrogenous manures. During the first year the nitrogenous manures were made up of sulphate of ammonia and nitrate of soda, while all the nitrogen was supplied as nitro-chalk during the second season.

It is also highly probable that the high percantage of organic matter in some of the upland soils is related to the recovery of nitrogen found in the pastures, it being possible that a considerable proportion of nitrogen was derived from this decomposed organic matter, and not from the nitrogen directly supplied by the manure. In Table VII the percentage organic matter in the three upland soils is given, together with the recovery of nitrogen effected in each instance.

Owing to the limited number of trials that have so far been conducted, a conservative attitude has to be adopted in arriving at conclusions from Table VII. It would, however, be difficult

to explain the exceptional recovery at Pensarn and Llety during 1928, except on the assumption that the nitrogenous manures used on the PKN plots had accelerated the decomposition of the large store of organic matter present in these soils. In the case of Foel the relatively low percentage of organic matter indicates

TABLE VII.

Showing the organic matter content of upland soils and the Nitrogen recovered from the pastures on those soils.

Soil.	*Per cent. organic matter.*	*Per cent. Nitrogen recovery.*	
		1927.	1928.
Foel ...	14.69	38	27
Pensarn ...	27.51	44	84
Llety ...	32.10	49	129

that the natural conditions were such as to favour more rapid biological changes than in Pensarn and Llety, and we find that the recovery of nitrogen is no more than would be reasonably expected from low yielding herbage under high rainfall conditions.

As nitro-chalk supplies lime as well as nitrogen it was thought that this lime might contribute towards an increased yield of this constituent from the plant. To what extent this has occurred can be seen from Table VIII.

From Table VIII it is seen that in the case of the lowland plots the yield of lime from the nitrogen plot is generally less than that from the no nitrogen plot. This is the case both in 1927 and 1928, and the nitro-chalk cannot be said to have made any contribution towards an increased yield of lime in the plant.

The position is, however, different in the upland plots. Here, especially on the soils rich in organic matter (Pensarn and Llety) a higher yield of lime is obtained from the nitrogen plots. We further find that the difference between the two series of plots was much greater in 1928 than in 1927, and it is likely that the lime of the nitro-chalk may have played an important part in bringing this about.

Summary and conclusions.

In the present article the recovery of nitrogen obtained as a result of the application of soluble nitrogenous manures to ordinary swards is considered. The data has been derived from the results of a series of experiments carried out over a period of two years by the Welsh Plant Breeding Station. In these experiments small pasture plots were treated at different centres with a basal dressing of potash and phosphate, while soluble nitrogenous manures were also applied in frequent dressings through-

out the growing season. At each centre a second plot was treated with potash and phosphate only, while a third plot, to which n

TABLE VIII.

Showing the effect of different Nitrogenous manures on the lime yield of pasture.

Locality.	*1927. Nitrogenous manures—Sulphate of Ammonia, Nitrate of Soda. Lime yield (lb. per acre).*			*1928. Nitrogenous manures—Nitro Chalk. Lime yield (lb. per acre).*		
	No Nitrogen Plot.	*Nitrogen Plot.*	*Diminution or increase in lime due to Nitrogenous manure.*	*No Nitrogen Plot.*	*Nitrogen Plot.*	*Diminution or increase in lime due to Nitrogenous manure.*
1. LOWLAND PASTURES.						
Rhoscellan ...	83.7	50.1	— 33.6	57.3	46.5	— 10.8
Nantcellan ...	93.7	89.0	— 4.7	84.1	77.8	— 6.3
Nantsiriol ...	58.5	61.8	+ 3.3	45.4	58.9	+ 13.5
Lluest ...	69.9	69.8	— 0.1	31.2	22.3	— 8.9
Bank ...	95.0	86.8	— 8.2	72.0	50.1	— 21.9
2. UPLAND PASTURES.						
Foel ...	28.2	28.0	— 0.2	51.4	59.5	+ 8.1
Pensarn ...	12.0	20.9	+ 8.9	12.6	43.6	+ 31.0
Llety ...	5.9	9.7	+ 3.8	10.3	40.6	+ 30.6

manure was applied, acted as a control. The produce of the plots was cut at monthly intervals. The results show that :—

1. In ordinary swards there are very large variations in the percentage of nitrogen which can be recovered in the produce from soluble nitrogenous manures.

2. Only a negligible recovery of nitrogen can be obtained from those swards rich in clover. This is shown to be due to a suppression of that component of the sward richest in nitrogen *viz.*, the clover, as a result of the application of soluble nitrogen.

3. An exceptionally high recovery of nitrogen can be obtained from certain upland swards. This high recovery is associated with upland swards containing a considerable proportion of moss and burnt herbage and lying on soils with a high organic matter content.

4. The recovery of nitrogen not only depends on the management of the herbage, but also on the botanical composition of the pasture and the chemical composition of the underlying soil. Thus a fertilizer treatment which might conceivably be profitable on one type of upland sward might not give a profitable return on another type of hill pasture.

5. It has been possible with the present experimental procedure in the field to demonstrate that applications of nitrogenous manures may or may not bring about an enhanced yield of nitrogen in the pasture. It is realised, however, that where enhanced yields occur, a different method of attack is necessary in order to determine that increased yield which can be correctly attributed to the nitrogenous manure. Such a method should specially aim at minimising those disturbing factors which have to be reckoned with on small plots.

6. Both the results from upland pastures as well as those results from pure species of grasses previously dealt with in this Journal (1) indicate that a certain portion of the enhanced nitrogen in the plant is derived from the soil and not the manure. Consequently a knowledge of the biochemical changes resulting in the hill soils from the application of nitrogen as well as the changes in the pasture from those soils is necessary in order to arrive at a true conception of the effect of soluble nitrogenous manures in these upland areas.

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THE EFFICIENCY OF THE MILKING MACHINE.

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Mechanical devices for the milking of dairy cows have been investigated under various conditions of structure and operation during the past fifty or sixty years. After many failures, it has now been possible to construct milking machines which will successfully milk cows. There are, of course, many types of these machines on the market, which differ from one another in construction and in many other details, but all of which operate on a system of intermittent suction and release. It is not proposed here to give a detailed account of the mechanism and mode of action of the milking machine, but rather to describe briefly the experience obtained with a mechanical milker during the past two years, which may be of some advantage to other milking machine operators.

An Alfa Laval Milking Machine consisting of three units was installed at the College Farm, Nantcellan, early in 1929, together with a 2½ H.P. Lister Engine to drive it. In this type of milking machine practically everything is standardised, as for example the vacuum and the pulsations per minute, with the result that there are but few adjustments to be made during a whole year, and none can easily be made to the machine during milking operations. It is well known that individual cows behave differently towards the machine, and for that reason, some types of machines are constructed so as to be adjustable to meet the pecularities of individual cows. As an example of this reaction of the cow to the machine, reference may be made to the time taken to draw milk from two particular cows in the herd, Rosie and Cochen. Rosie, yielding 16-20 lb. per milking, usually took ten minutes for the machine to draw 14-17 lb. left 2-3 lb. for the strippings, whereas Cochen, yielding 20-25 lb., took 5-6 minutes and left only ¼ to ½ lb. for the stripping.

The herd of Dairy Shorthorns which has been milked by this machine for the past two years has responded well to the mechanical method of milking. As has been previously indicated by Lush (1), and M'Candlish and Cochrane (2), there does not seem to be any great difference in yielding capacity between the machine and hand milked cows. High yielding cows may be machine milked without deleterious effects upon yield. In fact, it

seems that most cows prefer the machine to the ordinary hand milkers. The gentleness with which the mechanical milker operates has a calming effect upon the cow. This influence is also noticeable with nervous cows as well as with individuals suffering from sore teats and other superficial udder troubles—cuts, abrasions, &c. Similar results were obtained with first calvers. During the past two years 30 heifers have been put to the machine a few days after calving, and although some were uneasy during the first few milkings, especially those with hardened quarters, hardly any serious trouble was experienced. Even heifers with small teats, which are troublesome to milk by hand, are satisfactorily milked by machine, and provided the teat cup liners are tight, there is no danger of the teat cups falling off.

Disadvantages of the milking machine.

The capital outlay involved in the purchase and erection of a mechanical milker and of the power units required, together with the labour and fuel costs of operation, are naturally serious obstacles to its general adoption on dairy farms in this country. It should be mentioned, however, that there are other disadvantages in the use of the milking machine. For example, on farms where daily milk records are kept it is necessary to change the buckets in order to remove and weigh the milk of individual cows. Without a daily recording scheme it is not necessary to do this, until a bucket is nearly full, thereby saving a considerable amount of time. With weekly recording this trouble is considerably reduced.

Another drawback in the use of the machine, is the tendency with a number of cows to let down their milk immediately the engine is started. Apart from being unsightly, this is wasteful and difficult to overcome. It is, of course, the practice to put the machine on the worst offenders first, viz., the high yielders which are very easily milked. This tendency to let down the milk with the noise of the machine, was observed not only in mature cows in full milk, but also in cows over half-way through the lactation as well as with first calvers. The amount of milk lost through this is difficult to estimate, and may be very little, but with two or three exceptions, all the cows in the herd have been defaulters at some time or other. This reaction to the machine is most keenly felt at morning milkings when the cows come in from grass in May and June.

The third precaution to be taken with milking machines is careful and thorough stripping after the machine. With successful milking the amount of strippings thus collected may be ¼ to

½ lb. per cow. This precaution, however, should always be observed since occasionally some cows will not yield their milk quickly to the machine, and although the observation glass tube indicates that the milking is at an end, yet it may still be possible to draw 2-3 lb. in the strippings. Further, cows which are known to be hard milkers will yield more in the strippings than easy milkers. It may also happen on rare occasions that a teat has not been properly inserted in the teat cup, with the result that only a portion or even none at all of the milk would be removed from the quarter. Stripping after the machine is essential to avoid drying off the cows too soon, to obtain more milk of a higher quality, and as a precaution against udder trouble.

Another source of trouble that may occur is that the teat cups may fail to grip properly and thus fall to the ground. In this way the milk is contaminated through the suction of air or dust into the bucket. This trouble is to some extent due to worn teat cup liners, which cannot be fitted on sufficiently tight. It is also due to the lack of care exercised in fixing the teat cups to udder, consequently with a careless operator there is far more trouble in this direction than with efficient ones. This trouble may also be due to other reasons such as small size of teats, or to the shape of the teats or even to the rapidity with which the milk flows after the teat cups have been attached.

Risk of udder infection.

At one time in the past it was frequently stated that milking machines would carry infection from a diseased udder to a healthy one. This is difficult to disprove as even healthy udders do not yield sterile milk. On occasions the milking machine has been blamed for udder troubles in a herd, when actually the misfortunes were due to the udder flora developing the disorders, and not to the machine acting as a carrier of disease from cow to cow.

It is obvious that great care should be exercised in using the machine on doubtful quarters, and that special precautions regarding cleansing should be taken whenever such a misfortune may have occurred. In no instance at Nantcellan, as far as can be ascertained, has the machine acted as a carrier of disease. On the other hand, it is felt that the best treatment for sore teats and swollen quarters is the judicious use of the mechanical milker.

Advantages of mechanical milking.

The actual success in the daily running of the machine depends to a large extent on the reliability and efficiency of the

source of power. The petrol and paraffin engines in use are very satisfactory, yet they are open to occasional failures due to sooty plugs, magneto trouble, &c. Only on one occasion has there been a minor break-down in the milking arrangements at Nantcellan.

Taking everything into consideration, however, it seems that from the point of view of its influence upon the cow the mechanical milker is highly efficient. It is, however, necessary to consider the machine in its relation to farm labour, cost of running, cost of repairs and other incidentals.

After overcoming the initial difficulties the labourers on the farm have undoubtedly favoured the use of the machine. It is a great boon on farms where it is difficult to secure satisfactory hand milkers. Although any person with a little practice may be able to operate the machine yet it is essential, in order to get the best results, to have one man responsible for the machine and for the milking and final stripping of the cows. Without responsibility the machine may be a worse proposition than the worst possible lot of hand milkers. In this connection, dismantling, assembling, cleaning and sterilising play an important part in securing milk of a high hygienic quality. Daily dismantling would involve excessive labour costs on commercial farms, with the result that a modified scheme of cleaning by dismantling twice weekly has been practised. The daily cleaning methods adopted during the remainder of the week have been as follows. Immediately after each milking cold water and air are drawn alternately through the teat cups into the buckets, by immersing the teat cups in a tank of cold water and withdrawing to allow air to enter. After the morning milking the machine is partially dismantled, by removing tubes from bucket to claw, and from bucket to pipe line, removing the claw and connecting a pulsating rubber tubing to two separate teat cups, thus preventing water from getting into the pulsators. The buckets are emptied and again swilled out with water. The parts thus dissembled are then washed in hot soda solution, thoroughly scrubbed, and swilled out with clean water to remove the soda and finally placed in the steaming chest for thorough sterilisation. The assembling required after steaming in these cases only takes a few minutes for the three units. In the evening, however, after the cold water douching, as indicated above, a hot soda solution is drawn through the teat cups into the buckets a few times, all the parts easily available are thoroughly brushed inside and outside, and hot water is drawn through to remove the soda. After this the tubes connecting bucket and teat cups are removed

and the teat cups are hung up overnight. The milk tube is further treated with hot soda, a long wire brush worked through, and finally washed with water before putting up to dry. The buckets and lids are dealt with similarly.

In the case of the complete dismantling, the method of cleaning is the same, except that the teat cups are also dismantled and thoroughly scrubbed and sterilised. A freshly sterilised set of teat cup liners are now used in assembling the machine. In other words two sets of a dozen teat cup liners are used alternately, and this ensures the tight fitting which is essential for successful machine milking. It is difficult to estimate the cost of cleaning the milking machine as it is part of the time required for the washing and sterilising of other dairy utensils, but four to six hours a week would be the approximate time required.

Cost of machine milking.

An important consideration to one comtemplating the purchase of a new machine or implement is, of course, that of the cost of the spare parts, together with the cost of fitting these on, and the frequency of using new spares. With some types of machinery it is known that spare parts are not only costly in themselves but are expensive to fit on, especially when outside labour has to be hired for the purpose. With the milking machine under consideration the total costs of spares or replacements for the two years 1929 and 1930 are shown in the following table.

It will be seen that the chief items of the cost have been the rubber parts and of these the teat cup liners are the most important. In addition to the replacements, improved contrivances for fitting the liners have been included—these are in reality capital outlay and not replacements.

It will be seen that the costs shown in Table I for the past two years have been approximately £5 per annum and this includes over £1 per annum in new capital. Further, no extra expense has been incurred to fit on the spares, and there has been no expenditure on the vacuum pumps, the pulse relays and the pulsators, and no replacement of the original sets of twin rubber tubes.

The Table also shows that two dozen sets of teat cup liners used alternately remain in use for three months at a cost of 1½d. per day. The other items are negligible compared with this, although no account has been taken of the future needs of resoldering some of the side tubes on the metal teat cups.

In considering the merits or otherwise of a milking machine it is essential to study the running costs and to compare the cost of milking by hands with that by machine. It is obvious that manual labour is required to operate the machine, so that the saving, if any, in labour consists of reducing the milking staff. Thus two men accustomed to machine milking can manage at

TABLE I.

Cost of replacements, repairs and new equipment in connection with the milking machine for two years, 1929 and 1930.

	£	s.	d.
16 dozen teat cup liners	4	16	0
3 dozen short milk tubes	0	13	6
3 dozen short pulse tubes	0	15	0
½ dozen glass inspection tubes	0	3	6
3 long milk tubes	0	12	0
3 dozen washers (assorted)	0	7	7
Brushes	0	8	3
Repairs to pulse distributor	0	1	0
Repairs to bucket handle	0	12	0
New ring inserter	0	11	0
New liner stretcher	1	10	0
New tube remover	0	1	3
Total	£10	11	1

least 25-30 cows per hour with three units, *i.e.*, allowing an average of six minutes per cow, whereas four at least, and probably five, hand milkers would be required for the same work in the same time. With larger herds a greater saving of labour is possible, whereas with smaller herds of twelve to twenty cows, there may be no economy of labour.

This saving of manual labour is, naturally, important where there is a scarcity of efficient hand milkers. It is also important on dairy farms during the hay and corn harvest, where it becomes necessary to split up the gang of workmen and thus delay the harvest work for the purpose of completing the milking by a certain time in the forenoon. At other times of the year this splitting up a gang is not so important, but during the harvest especially in precarious weather, the delay may mean the failure to secure tons of good hay in prime condition, which may be worth more than the value of the manual labour or of the running cost of the milking machine for many months.

The actual costs of operating the milking machine for the past two years at Nantcellan are shown in the following table. The largest item of the total cost is seen to be that of power

supply, namely the running costs of the petrol engine, in the way of petrol, oil, spares, decarbonising and lubricating oil.

The yearly costs of running the milking plant at Nantcellan as shown in Table II works out at approximately 7/- per week, compared with 10/- per week for one hand milker hired for milking only. The petrol account appears to be high, but it must be borne in mind that the consumption of fuel is abnormally high for some months at the commencement until the workers have gained sufficient experience.

TABLE II.

Cost of petrol and lubricating oil for running of the milking machine for two years, 1929 and 1930.

	£	s.	d.
Petrol.			
36 galls. Commercial Petrol @ 1 2¾	2	4	3
374 ,, ,, ,, @ 1/5	26	9	10
18 ,, ,, ,, @ 1/3	1	2	6
42 ,, ,, ,, @ 1 2½	2	10	9
2 ,, Lubricating Oil for Engine @ 5/6	0	11	0
3 ,, ,, ,, ,, Pump @ 6/-	0	18	0
Decarbonising Engine, grinding valves, etc.	2	4	0
	£36	0	4

Further, the account shows that the price of petrol varied considerably during the two years, and for the major portion of the period its price was 1/5 per gallon.

On the other hand the total costs in connection with machine milking, where depreciation, interest on capital, and labour are taken into consideration is shown in Table III.

TABLE III.

Estimate of total cost of running milking machine for two years, 1929 and 1930.

	£	s.	d.
Total cost of repairs and replacements, etc. (Table I) ...	10	11	1
Total cost of fuel, lubricating oil, etc. (Table II) ...	36	0	4
Depreciation and interest on capital	35	0	0
Labour: Cleaning, washing, etc.—4 hours per week @ 7d. per hour	11	13	4
	£93	4	9

In the above table 10 per cent. is allowed for depreciation and 5 per cent. interest on capital. These figures may or may not be excessive but with this allowance the weekly account

comes for the first two years of operation at nearly £1 per week. In other words it is equivalent to the wages of two extra hand milkers at 10/- each per week.

On the other hand, the troubles often experienced with hand milking such as holidays, illness, inefficiency, &c., are considerably reduced with machine milking, and further the machine gives a feeling of independence on outside labour to the person in charge of the dairy herd.

Bacteriological efficiency.

There is a widely-spread belief that milking machines under ordinary farming conditions cause heavy bacterial contamination of milk.

During the latter years of the European War a large number of machines of various kinds were installed in South Wales. Unfortunately most of these were abandoned after a few years, mainly due to various mechanical causes and to the lack of care in cleaning.

It has been thought, therefore, that dairy farmers who are contemplating the installation of a modern milking machine would be interested in the results of the bacteriological examination of milk samples taken at regular intervals for three years previous to, and for two years after the installation of a milking machine at Nantcellan.

In addition to the results obtained during the examination of routine milk samples, the bacterial flora of aseptically drawn milk was investigated from time to time.

A comparison was also made of the bacterial content of milk drawn by hand and by machine.

Bacterial content of the udder.

Farmers generally and particularly those producing "Graded" milk are interested in the extent that the initial udder flora can influence the bacterial count of milk.

A large number of bacteriologists have worked on the bacterial flora of the udder, and it has been known since 1900 that the orifice of the teat, the milk cistern and the larger milk glands do contain a small number of bacteria.

A certain number of bacteria are capable of withstanding the bacteria inhibiting properties of the udder tissues, and it has been shown that the number of bacteria in each healthy quarter remains practically unchanged during considerable periods.

Information from the literature dealing with the flora of the udder is summarized by Dorner (3) as follows :—

Author.		*Average count per c.c.*	*Number of cows.*
Schulz	(1892)	2,330	—
Russell	(1894)	330	—
Marshall	(1900)	295	—
Freudenreich	(1902)	295	—
Lux	(1903)	1,391	10
Harding and Wilson	(1913)	428	78
Burri and Hohl	(1917)	347	16
Copeland and Olson	(1926)	1,546	40
Alice F. Breed	(1928)	964	12

An examination by Dorner of 993 samples of asceptically drawn milk from 132 cows belonging to six herds gave average counts for individual herds varying from 530 to 4,390 per c.c. on standard agar plates.

An occasional cow is found to give consistently high counts for long periods. Hastings and Hoffmann (4) cite a case where an average count of 88,000 per c.c. was observed over a period of two years.

The bacterial content of the fore-milk, mid-milk and strippings of individual cows at Nantcellan was obtained on several occasions. The milk was drawn into sterile bottles with aseptic precautions. One cubic centimetre and one-tenth of a c.c. were then plated in duplicate on standard agar within an hour of milking.

TABLE IV.

Cow.	*Fore milk.*	*Mid milk.*	*Strippings.*
Berriers II	3,040	304	574
Laura II	310	13	455
Diddig	13,360	2,600	310
Nancy III	11,520	1,850	760
Polly Ddu	584	762	102
Jean	1,680	709	125
Betsy IV	3,780	376	210
Berriers III	180	66	50
Nancy IV	7,800	6,000	1,025
Mabel	20,800	810	788
Nancy Pet I	1,120	—	760
Del	2,400	—	1,600
Berriers V	42	—	31
Lassie	920	—	360
Molly	7,200	—	2,800
Ystwyth Mist	6,640	—	405
Nancy Pet IV (inflamed quarter)	11,200	—	5,000
Nancy Pet IV (normal quarter)	55	—	20
Sybil (inflamed quarter) ...	156,000	—	2,460
Sybil (normal quarter)	1,450	—	540

When the fore-milk was discarded it was found that the normal udder content was not high enough to cause excessive counts in market milk.

In the case of inflamed quarters, however, counts of several thousands bacteria per c.c. were generally found, and it is probable that in such cases the bacterial count of the market milk is affected adversely.

The above table is given as an example of the results obtained. These were obtained from eighteen cows during an evening's milking.

Omitting the two abnormal quarters, the following averages are obtained in this case :—

Fore milk	...	...	...	4,605 per c.c.
Mid milk	...	...	...	1,329 ,, ,,
Strippings	...	...	...	662 ,, ,,

The bacterial content of the fore-milk is about eight times that of the strippings and shows that discarding of a few squirts of fore-milk is justifiable.

Microscopical examination of the colonies has shown that micrococci predominate on agar plates poured by the standard technique. Most of these organisms have been found to be either inert or having very little action on sterile milk during seven days at 22°C.

As Dorner points out much more work should be carried out along these lines, as there are many important problems in connection with the qualitative nature of the udder flora still unsolved.

Routine milk samples.

The routine examination of cooled bulk milk was carried out at twenty-eight hours after milking in the case of morning milk and at twenty-four hours old with evening milk. The samples were plated on standard agar and incubated for forty-eight hours at 37°C. *It should be noted that the milk in all cases was examined at "standard" ages, and not a few hours after milking.*

Table V shows the results for 121 samples taken before installing the machine and 117 samples after installation.

These few samples show that the hygienic quality of the milk is quite as good during the period of machine milking as that produced by hand, 56 per cent. of the samples being below a count of 20,000 in the former as compared with 54 per cent. in the latter. The majority of the samples placed in the group

having a bacterial count of over half a million were taken during the course of a period of five days when the sterilization of the equipment was found to be defective.

TABLE V.

Bacterial count per c.c.	HAND MILKED. *Per cent. samples in group.*	MACHINE MILKED. *Per cent. samples in group.*
Under 5,000 ...	31	32
5,001– 20,000 ...	41	24
20,001–100,000 ...	26	24
100,001–200,000 ...	6	4
200,001–500,000 ...	6	4
Over 500,000 ...	8	12
	100	100

Qualitative examination of milk flora.

A comparison of the types of bacteria present in low count milk and in high count milk during mechanical milking was carried out. Three hundred colonies were picked from plates giving counts under 20,000 per c.c. and inoculated into sterile litmus milk tubes.

Similarly 330 colonies were picked from plates giving counts of over 500,000 per c.c. The litmus milk tubes were incubated for four days at 37°C and the types of fermentations classified as Acid Curdling, Weak Acid, Inert, Alkaline, and Peptonizing. The results are shown in Table VI.

TABLE VI.

	Action on sterile litmus milk.			
	Acid curdling.	*Weak Acid.*	*Inert and Alkaline.*	*Peptonizing.*
	per cent.	per cent.	per cent.	per cent.
Low count milk (under 20,000 per c.c) ...	59.3	15.5	21.2	4.0
High count milk (over 500,000) ...	20.0	25.0	12.5	42.5

As previously stated the high counts were mainly due to faulty sterilization. It is interesting to note, therefore, the preponderance of peptonizing organisms in the milk samples included in this group. In carrying out another investigation

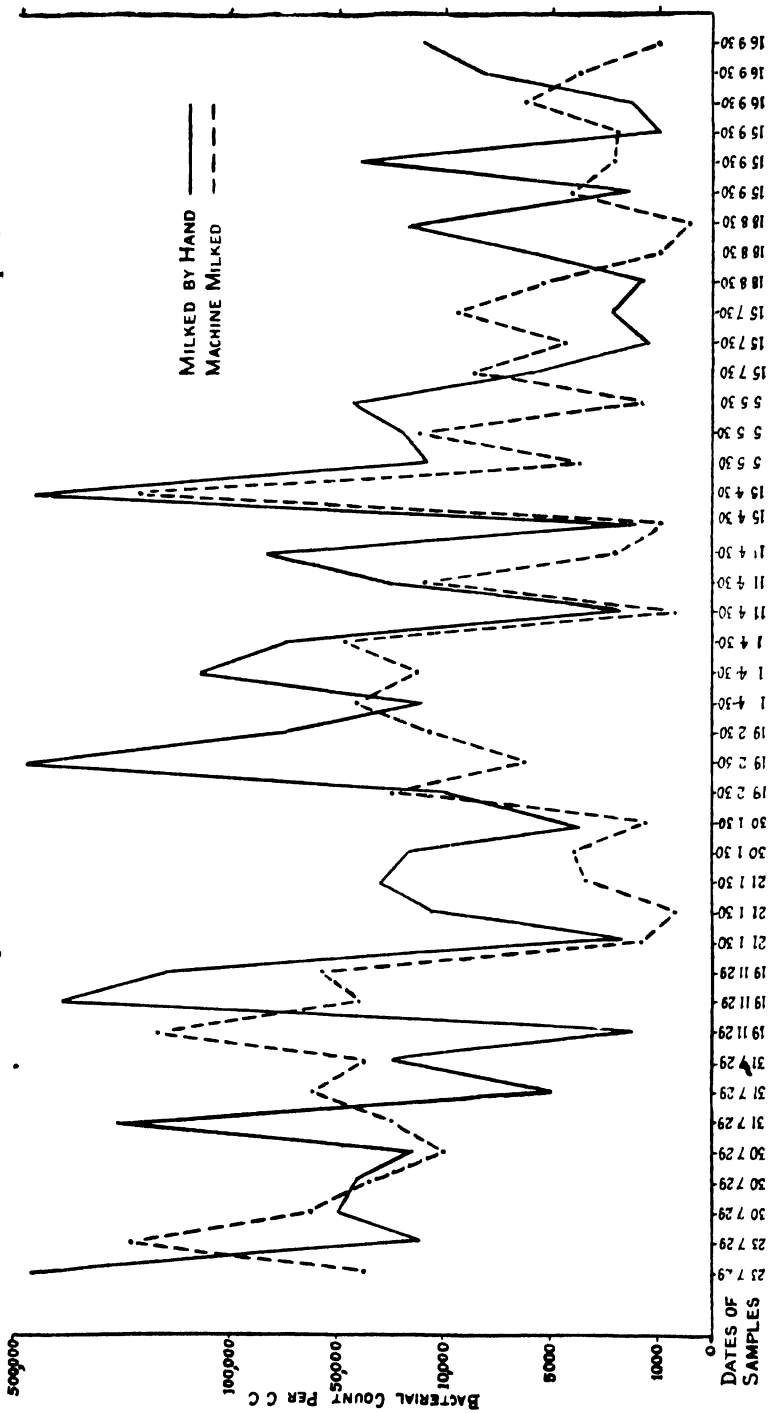

CHART 1. Comparison of bacterial counts of hand and machine milked samples.

with samples from the same source and during the same period it was found that a considerable number of these peptonizing organisms were thermoduric (heat resisting), spore forming rods, whilst a few of these spore formers were actually thermophilic (heat loving), reproducing at a temperature as high as 56°C.

Coliform organisms.

Of the 117 machine milked samples examined, 44 per cent. were found to have Coliform organisms absent in one cubic centimetre, 26 per cent. present in 1 c.c., 17 per cent. present in 1/10 c.c., 9 per cent. present in 1/100 c.c., and 4 per cent. present in 1/1000 c.c.

Official "Graded" samples.

Twenty-two milk samples have been taken, since the installation of the machine, by the Welsh Board of Health in connection with the Milk (Special Designations Order). Only two (9 per cent.) of these failed to attain Grade A Standards. This result compares very favourably with figures for 250 Official Graded Samples examined at Aberystwyth. In the latter case 12.4 per cent. of the samples failed to attain the desired grades.

Hand versus machine milking.

In order to compare the respective merits of hand and machine milking, three cows were milked by hand and three by different units of the machine and samples taken from each at the same time. The milk was cooled in the sample bottles and examined at twenty-four and twenty-eight hours old. The cows used in the experiment were changed regularly so that practically all the herd was included under both conditions.

TABLE VII

Coliform organisms.	*Samples milked by machine.*	*Samples milked by hand.*
Absent in 1 c.c. ...	29	25
Present in 1 c.c. ...	4	4
Present in 1/10 c.c. ...	2	3
Present in 1/100 c.c. ...	3	4
Present in 1/1000 c.c. ..	4	6
Total number of samples ...	42	42

It can be seen from the results given in Chart I that the bacterial counts for the machine milked samples taken as a whole

are quite as low as those for the hand milked samples, the trend of results for the former being, if anything, slightly lower. Similarly the tests for Coliform organisms gave results favourable to the machine milked samples.

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SOME FACTORS INFLUENCING THE KEEPING QUALITY OF BUTTER.

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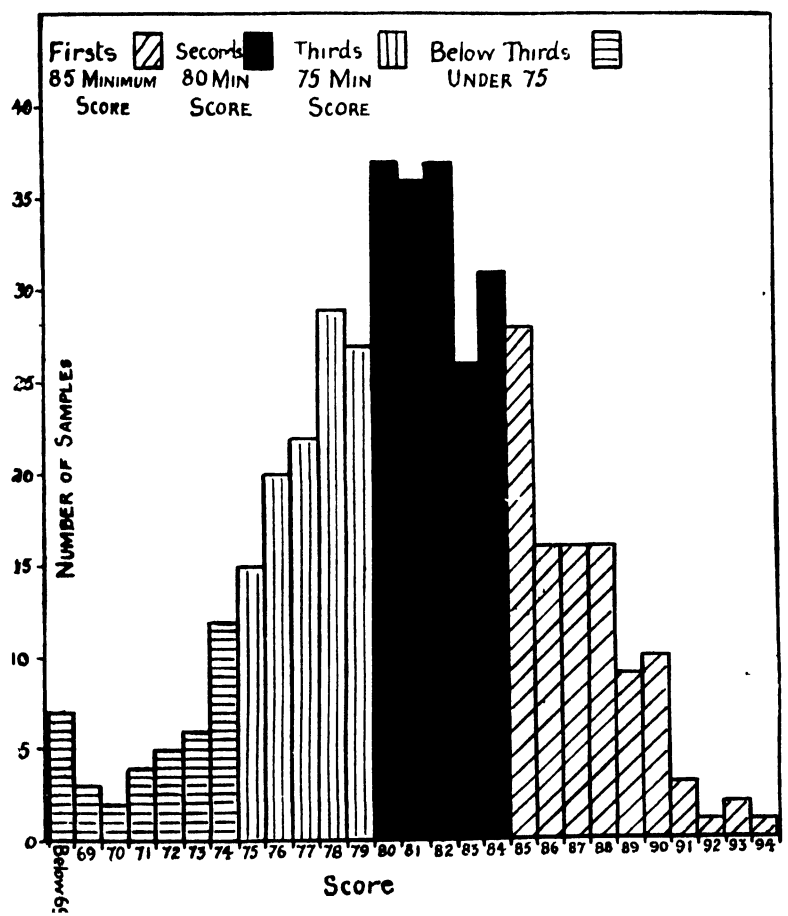
It is evident that farm butter producers are beginning to realise the importance of producing an article of good and uniform quality. While the best farm produced butter is of excellent quality, there is far too much of the inferior article on the market, with the result that consumers are often unable to place any real confidence in their farm butter supply and are taking to the use of imported and blended butter. Such butter, although not of the best quality, has the advantage of uniformity of quality and flavour. If British producers are to compete successfully with imported and blended butter, then they must be prepared not only to place on the market a product of superior quality but one which is uniform throughout the year. This is undoubtedly the only way in which we can hope to maintain the confidence of the consumer. Good quality butter in addition to possessing a pleasant flavour and aroma, good body, and pleasing appearance, should possess a good keeping quality. A butter which is capable of keeping free from taints for three weeks or more is an infinitely better commercial article than one which is capable of retaining its natural flavour and aroma for only a period of a week or so. It may seem that a keeping quality of twenty-one days is unnecessary, since most farm butter is

consumed within a week of churning. From a laboratory standpoint such a keeping quality indicates the hygienic measures taken during production.

During recent years Local Authorities have realised the importance of encouraging producers to manufacture a superior quality butter, and it was felt that this could usefully be accomplished through the medium of Butter Competitions. Six such competitions have been held in the Aberystwyth Advisory Province. Competitors sent samples of unsalted butter, milk, and cream at regular intervals to the Agricultural Department of the College, where they were graded and examined bacteriologically. Up to date four hundred samples have been examined.

CHART 1.



Judging and Grading.

Immediately on arrival at the College each sample of butter was judged on the basis of the score card given on page 301 of this volume. Practically all samples were examined within twenty-four hours of churning.

Those samples which on judging possessed a pleasant flavour and aroma, a good body, texture, and colour, which did not contain an excess of moisture, and which scored a minimum of eighty-five marks, were graded " Firsts ".

Samples showing slight defects under the above-mentioned headings and which were awarded a total score of eighty to eighty-four inclusive were graded " Seconds ". Butter with more pronounced " off flavours " and other serious defects, with a total score of seventy-five to seventy-nine inclusive, were graded " Thirds ".

The above Chart shows the distribution of the samples in the various grades.

Keeping quality.

After judging, the samples were placed in a low temperature incubator at a constant temperature of 60°F., and tested at regular intervals. When a sample developed a flavour or defect that would condemn it for household use it was discarded. The keeping quality is expressed as the number of days which elapse between the date of churning and the time of discarding.

The average keeping quality of 410 samples examined was fifteen days. The range and distribution of keeping qualities are summarised below :—

Keeping quality. Days.	*General quality of group.*	*Number of samples.*	*Per cent*
4– 7 days.	Poor.	30	8
8–12 days.	Fair.	96	24
13–17 days.	Good.	163	37
18–22 days.	Very good.	83	21
23–26 days.	Excellent.	38	10

Approximately 70 per cent. of these samples attained a keeping quality of two weeks or more, and only 8 per cent. were discarded within a week of churning. In our opinion a really superior sample should attain a keeping quality of at least eighteen days. Only 31 per cent. of the samples examined attained this standard.

Milk production.

Hygienic milk production is essential for the optimum development of true lactic acid bacteria during cream ripening. Unless really clean milk is produced, no matter what skill and care is taken during the ripening of the cream, and in the actual churning and working, a first grade butter cannot be obtained.

An ideal milk for the purpose of natural cream ripening should be free from coliform as well as peptonizing and putrifying organisms, so as to give free scope for the development of the desirable lactic acid bacteria.

The bacterial count of the milk gives an indication of the hygienic precautions taken during production, and furthermore a high count milk will be more likely to contain undesirable organisms from the point of view of cream ripening than a low count milk.

Practically 40 per cent. of several hundred milk samples examined during the course of the butter competitions failed to attain Grade A bacteriological standards.

The majority of these comparatively high count samples contained coliform organisms in as low a dilution as 1/1,000th of a cubic centimetre.

A bacteriological examination of the cream produced from the high count milk generally showed coliform organisms present in 1/100th, 1/1,000th, and even 1/10,000th of a cubic centimetre.

The following table shows the results of the bacteriological examination of milk samples from butter producing farms :—

Competition.	*No. of Competitors.*	*No. of Milk samples.*	*Per cent. Milk samples not attaining Grade A bact. standards.*	*Per cent. Milk samples with coliform organisms present in 1/100th cc.*
Pembroke 1928	12	15	50	50
Pembroke 1929	12	27	0	0
Pembroke 1930	15	26	55	36
Brecon & Radnor 1929	14	56	38	30
Merioneth 1930	9	16	56	13
Cardigan 1930	17	53	50	17
Random samples	—	136	37	31
Totals	77	329	—	—

Of forty cream samples examined from butter producing farms during periods when high bacterial counts were found in

their milk, thirty-five showed coliform organisms present in 1/100th or 1/1,000th cubic centimetre.

It has been found that the presence of a large number of these gas producing, pseudo lactic acid organisms in ripened cream has a deleterious effect on the keeping quality of the butter.

The presence of excessive numbers of peptonising and putrifying spore forming organisms in the milk is generally due to contamination from dusty cowsheds, hay, and straw; this leads to faulty cream ripening and often gives rise to early development of rank and objectionable taints in the butter.

The results of all the butter competitions prove that hygienic methods of milk production are quite as important on the butter making farms as on milk retailing farms.

Cream separation.

Cream is liable to be heavily contaminated with injurious organisms during the process of separation; and unless all the parts with which it comes into contact are kept scrupulously clean the subsequent fermentations cannot be controlled.

The separator bowl should be taken apart and along with other removable parts washed and sterilised with boiling water or steam after each separation. It has been found that flushing out with cold or hot water is the only measure adopted on many Welsh farms, especially after evening separation. The slime deposited in the bowl is not removed, and it serves as a breeding ground for particularly harmful organisms which will contaminate the following morning's cream. An examination during summer months of samples of separator slime, twelve hours or so after being deposited, has shown the presence of large numbers of spore forming organisms.

Cream containing 25-30 per cent. of fat is considered to be the most satisfactory for ripening and churning purposes. Several cream samples examined have been found to exceed this limit. This generally leads to difficulties, such as Sleepy Cream.

Cream ripening.

Advisory work carried out for producers in West and Mid Wales during the past four years has shown that much inferior quality butter is the result of faulty methods of cream ripening. The chief contributory causes are :--

1. Unsuitable ripening temperatures.
2. Over ripening.

Constant temperatures between 60° and 68°F. produce the most satisfactory ripening. The aroma producing bacteria do

not thrive well above this limit, while the lactic acid organisms are apt to lose their virulence below 60°F. Several off-flavours and defects of texture, such as bitterness, oiliness, and weak body are often the result of unsuitable ripening temperatures.

Bacteriological studies have shown that the development of maximum bacterial count is reached when the cream thickens. Lactic acid bacteria are found to predominate at this period, which during summer months is often reached within two days of separation. If the cream is allowed to ferment beyond this point the most desirable lactic acid bacteria will be suppressed, and undesirable organisms, such as peptonising bacteria, will develop, often imparting a strong aroma to the butter and at the same time reducing the keeping quality.

The churning of over-ripe cream generally produces sour and unclean flavours, and these have been the predominating taints developed in samples examined at the laboratory.

Cream containing 0.45 per cent. acidity may be regarded as ideal for churning purposes; churning should therefore be carried out at least twice a week. If the desired condition is reached before the time of churning, further bacterial activity should be checked by cooling. The formation of localised areas of fermentation is prevented by stirring the cream at intervals, in order to distribute the souring organisms evenly throughout. Cream of different ages should not be mixed within twelve hours of churning, otherwise a butter of uneven quality will be produced. The ripening process should be carried out in a clean, well-ventilated dairy free from food odours which may be absorbed by the cream.

The effect of ripening cream by means of a Starter is being investigated by the Dairy Bacteriologist at Bangor. The results so far obtained show an improvement of two to three days in the keeping quality of the butter produced by this method.

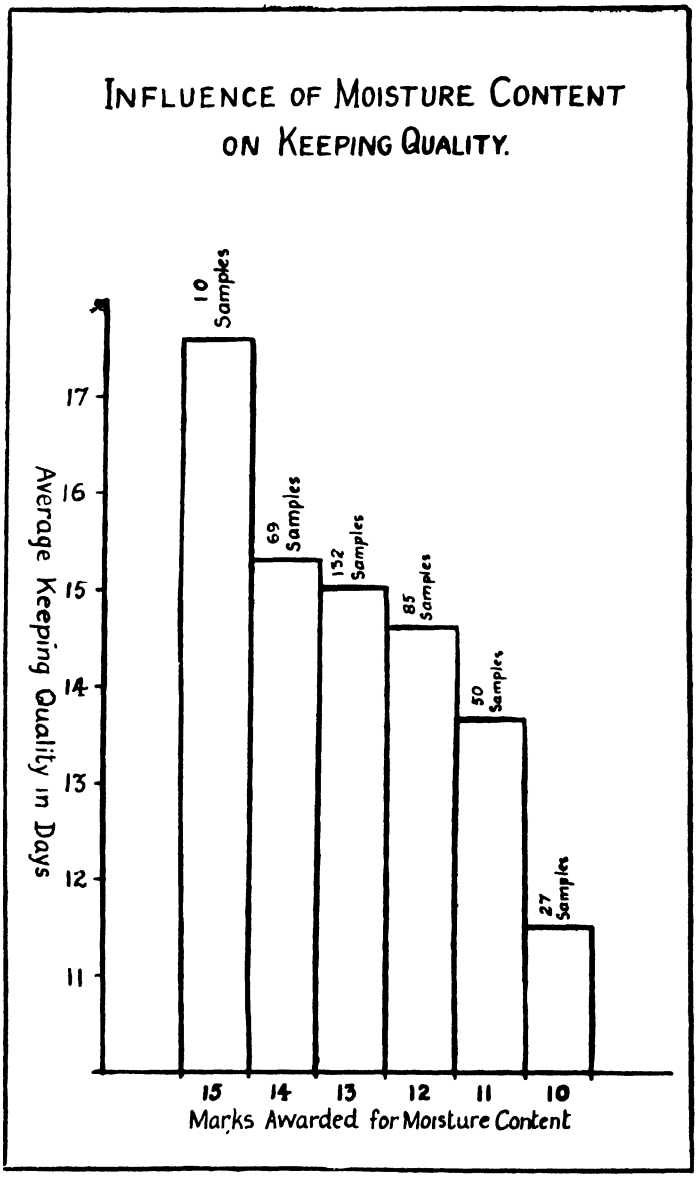
Churning and working.

The lower the temperature at which churning may be successfully completed the better. With a high churning temperature difficulty will be experienced in obtaining a satisfactory grain; further, the resulting butter will be soft and greasy, and there will be a greater loss of fat in the buttermilk. In the production of a long keeping butter it is essential that the grains are washed free of buttermilk; where butter is churned into a lump this becomes impossible.

A large number of the samples examined at the laboratory showed the presence of strong traces of buttermilk, and these samples had invariably a poorer keeping quality than those in

which the moisture was quite clear. A very high proportion of the samples contained an excess of moisture. While the law permits a maximum of 16 per cent. moisture in butter, it is generally agreed that the best quality should not contain more than 13 per cent.

CHART 2.



During judging, a maximum of fifteen marks were awarded for correct incorporation of moisture, whilst marks were deducted

for an excess of free moisture content. An analysis of the results shows that samples " leaky " in body and texture do not attain a good keeping quality.

Samples scoring full marks (15) for moisture content had an average keeping quality of 17.5 days while those samples only scoring ten marks had a keeping quality of 11.5 days.

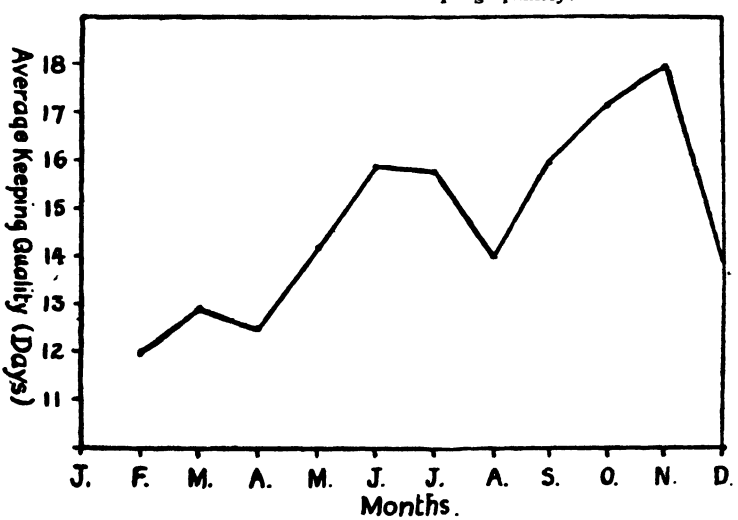
It is important that the water used in washing the butter should be free from certain types of undesirable bacteria, such as the coliform group, fluorescent group, spore formers, and other proteolytic types. Of approximately 150 water samples taken from shallow wells in rural districts, 50 per cent. were found by bacteriological tests to contain coliform organisms in high dilutions. It was also found that fluorescent bacteria were present in a considerable number of water samples. It is a well-known fact that this group of organisms are responsible for the development of rancidity in butter. The water should also be free from iron deposits, as this tends to develop a tallowy flavour.

Seasonal influence.

It is generally considered that the keeping quality of butter is at its lowest during the winter months. It was therefore thought that it would be of interest if the monthly variations in the keeping quality of the 410 samples examined were studied. The results so far obtained are too few to base any definite conclusions, but the following Chart shows that there is considerable seasonal variation.

CHART 3.

Seasonal influence on keeping quality.



These results show that poor keeping qualities are experienced from December to February, possibly due to the fact that at this period a large proportion of the milk is derived from cows that are drying off. From April to June there is a steady improvement in keeping quality, and this coincides with spring calvings, and the turning of cows out to grass. A slight drop in keeping quality is experienced during July and August, which are the warmest months of the year. There is a further improvement during the next three months, due possibly to lower temperatures and better control of ripening. It will be seen that the best quality butter is produced during Spring and Autumn.

GUIDE TO THE CONDUCT OF BUTTER COMPETITIONS.

By S. B. Thomas, M.Sc.,

AND

G. T. Morgan, N.D.A., N.D.D.

University College, Aberystwyth.

The first Better Butter Competition to be organised in the United Kingdom was that arranged by the Pembrokeshire Agricultural Education Committee in conjunction with the Agricultural Department of the University College of Wales, Aberystwyth, during 1928.

This proved so successful that further competitions were organised in the county during 1929 and 1930. The County Agricultural Authorities for Brecon and Radnor, Cardiganshire, and Merionethshire have held similar competitions during the last two years.

There is every indication that similar competitions will be held in several other areas during the coming season. This provisional guide, which is the result of experience gained during the conduct of the above mentioned competitions, has been prepared as a possible basis for the conduct of future Butter Competitions in the Aberystwyth Advisory Area.

Objects of a Butter Competition.

The principal objects of a butter competition are to improve and standardize the quality of farm produced butter. This involves the manufacture of butter, the flavour, texture, and composition of which is good and uniform throughout the year.

Although grading according to flavour, aroma, texture, moisture content, and colour gives a fairly reliable indication of the quality of a sample of butter, the best criterion of quality from both the laboratory and commercial standpoints is the keeping quality at a standard temperature.

The art of producing butter which will both grade and keep well is not limited to the actual churning and working. The care and hygienic precautions taken during milking, separating, and ripening the cream, particularly the thorough sterilization of all utensils, are important factors in the ultimate quality of the product.

It is essential, therefore, that a scheme for the organization of a butter competition should include an inspection of the equipment and methods used in the production of milk, the separation and ripening of cream, the churning and working of the butter, as well as a laboratory examination of milk, cream, and butter.

Conditions governing competitions.

Period of competition.—Competitions of twelve months' duration are highly desirable. In any case a competition should extend over both winter and summer months, so as to afford an opportunity for a study of the influence of seasonal factors.

Sampling.—Triplicate sampling is advisable, that is milk, cream, and butter samples should be forwarded to the laboratory on the same day.

(*a*) Milk in sterilized eight ounce bottles. Evening's milk to arrive at the laboratory within twenty-four hours of milking, and morning's milk within twenty-eight hours.

(*b*) Fresh *sweet cream* in sterilized four ounce bottles to be despatched as soon as possible after separating and to arrive at the laboratory within twenty-four and twenty-eight hours of milking as above.

(*c*) Four to six ounces of *fresh unsalted* butter to be forwarded to the laboratory within one day of churning

At least one of these triplicate samples should be taken during each of the four seasons. In the case of six or twelve samples being taken from each competitor, equal seasonal distribution should be aimed at.

In addition, two or more representative samples of the *water used during butter working* should be taken by the inspecting judge during advisory or inspection visits and forwarded to the laboratory. Water samples for bacteriological purposes can be taken in the sterilized 8oz. bottles.

Scales of marks and system of judging.

The relative efficiency of competitors should be recorded in the form of marks based on a possible maximum of 1,500, divided between conditions of production and the examination of milk, cream, and butter.

A. Judging on the farm		600
1. Milk production	150	
2. Sediment test of milk on farm	100	
3. Separation of cream	30	
4. Cream and cream ripening	100	
5. Churning	120	
6. Butter working, packing and storage	100	
B. Laboratory examination		900
1. Bacterial content and keeping quality of milk	200	
2. Scoring and bacterial content of cream ...	100	
3. Grading of butter	300	
4. Keeping quality of butter	300	
		1,500

Judging on the farm.

Marks should be awarded according to the Inspection Report Card given on page 303.

The sediment test of the milk should be carried out by the Inspecting Judge during the actual milking. Separate tests from individual milkers are recommended. Full instructions for the proper use of the test during competitions is given on page 6 of the " Guide to Clean Milk Competitions " (Third Edition), 1928.

Laboratory examination.

(*a*) MILK.—The milk samples to be examined for bacterial content and keeping quality according to the standardized technique outlined in the above-mentioned " Guide ". The proportion of marks to be allocated as follows :—

	Maximum.
Bacterial count	300
Presence or absence of coliform organisms	200
Keeping quality test	300
	800

Although no marks are awarded for the butter fat content, the fat content of each sample should be determined for advisory purposes, as well as for detecting abnormal sampling.

(*b*) CREAM.—The following score card is used for the laboratory examination of sweet cream :—

Score Card I.

	Maximum score.	*Score obtained.*	*Remarks.*
Flavour	30		
Body and texture .	15		
Colour .	5		
Acidity .	15		
Fermentation test	15		
Presence or absence of coliform organisms	20		
	100		

In addition to the usual examination for flavour, texture, colour, and acidity, tests are made for the type of fermentation set up after incubation at 37°C. for twenty-four hours, as well as the presence or absence of coliform organisms in dilutions of 1 cc. to 1/1,000 cc.

Sweet cream with 0.20 per cent. lactic acid is awarded maximum score. With reference to texture, even consistency and a fat content of 30 to 35 per cent. are taken as the ideal standards.

An even, non-gassy clot on fermentation at 37 C. is awarded full marks. The majority of the samples examined to date have been found to contain coliform organisms in very low dilutions. The scoring for the results of this test is carried out as follows :—

Coliform organisms absent in 1 cc	20 marks.
Coliform organisms present in 1 cc	18 marks.
Coliform organisms present in 1 10 cc.	14 marks.
Coliform organisms present in 1 100 cc ..	8 marks.
Coliform organisms present in 1 1000 cc	0 marks.

(*c*) BUTTER.—Butter samples are judged on the day of arrival at the laboratory. It is important that tests on unsalted butter be carried out within thirty hours of churning. The score card used for judging is as follows :—

Score Card II.

	Maximum score.	*Score obtained*	*Remarks.*
Flavour and aroma ..	50		
Texture	25		
Freedom from moisture ..	15		
Colour ...	10		
	100		

The samples are graded according to the following scale :—

	Minimum score.
" Firsts " grade	85
" Seconds " grade	80
" Thirds " grade	75

After internal portions of each sample have been placed in sterile kali bottles for microbiological examination, the butter is placed in a 60°F. " low temperature incubator " and tested for the development of off flavours and defects at regular intervals. The score card suggested for awarding marks for keeping quality is given below :—

Score Card III.

KEEPING QUALITY OF UNSALTED FARM BUTTER.

Keeping quality.	*Marks.*
21 days and over	100
20 days	96
19 ,, ...	92
18 ,, ...	88
17 ,, ...	84
16 ,, ...	80
15 ,, ...	76
14 ,, ...	72
13 ,, ...	68
12 ,, ...	64
11 ,, ...	58
10 ,, ...	52
9 ,, ...	46
8 ,, ...	40
7 ,, ...	32
6 ,, ...	24
5 ,, ...	16
4 ,, ...	8
3 days and under	0

This table is based on an average keeping quality of fifteen days for 410 samples of unsalted farm butter tested during the course of six county competitions.

Microbiological examinations should be carried out as a check on the scoring and keeping quality tests. They are of considerable help in determining the cause of the development of taints of biological origin. The following tests are recommended :—

1. Determination of yeast and mould content. Acidified Malt agar (pH 3.5) at 22°C. for five days.
2. Determination of proteolytic bacterial content. Frazier and Rupp's Casein agar (pH 7.0) at 22°C. for five days.
3. Coliform organism test.

4. Incubation of warmed portions of sample at 22°C. for rapid development of off odours.

Reports and awards.

Interim and final reports should be sent out to each competitor, code numbers only being given. No names of competitors should appear in the final results except those of winners of prizes and awards of merit.

In addition to schemes of prizes, certificates of merit should be awarded to competitors gaining not less than 66 per cent. of the total marks.

Inspection Report Card.

Milk Production. (150).	*Maximum marks.*	*Marks awarded.*
(*a*) HEALTH OF COWS (50)	50	
(*b*) EQUIPMENT (20).		
Accommodation for cows	8	
Utensils used in milk production, straining, etc.	12	
(*c*) METHODS (80).		
Cleaning of cows	10	
Cleanliness of cowshed and surroundings	9	
Cleaning and sterilization of milking utensils	30	
Manner and Method of milking ..	25	
Handling milk, including straining .	6	
	150	

Separation of Cream. (30).	*Maximum marks.*	*Marks awarded.*
(*a*) EQUIPMENT (10).		
Separating room	5	
Separator	5	
(*b*) METHODS (20).		
Cleanliness of separating room and surroundings	5	
Cleaning and sterilization of separator	15	
	30	

Cream and Cream Ripening. (100).	*Maximum marks.*	*Marks awarded.*
(*a*) EQUIPMENT (15).		
Cream ripening room and cream receptacles	15	
(*b*) METHODS (85).		
Management of cream .. .	35	
Cream: flavour, aroma, and acidity .	40	
Cream: texture and colour	10	
	100	

Churning. (120).	*Maximum marks.*	*Marks awarded.*
(*a*) EQUIPMENT (20).		
Churning room	6	
Churn and utensils	14	
(*b*) METHODS (100).		
Cleanliness of churning room and surroundings	20	
Preparation of churn and utensils ...	15	
Use of thermometer and skill in churning	30	
Condition of grain	20	
Washing of butter	15	
	120	

Butter Working, Packing, and Storage. (100).	*Maximum marks.*	*Marks awarded.*
(*a*) EQUIPMENT (20).		
Butter worker and utensils	20	
(*b*) METHODS (60).		
Preparation of worker ..	15	
Working of butter	20	
Salting	10	
Making up	15	
(*c*) PACKING AND STORAGE (20)	20	
	100	

THE INFLUENCE OF THE FAT CONTENT ON THE KEEPING QUALITY OF MILK.

By S. B. THOMAS, M.Sc.,

AND

HETTY JONES, N.D.D.,

University College, Aberystwyth.

There is a belief, in the commercial side of the dairy industry, that rich milk becomes tainted sooner than average milk. It is quite possible that this belief is due to the fact that the cream layer may on occasions absorb taints and odours from the surrounding atmosphere. Barkworth (1) has shown recently that if " rich milks are considered in terms of butter fat content they loose little if anything in keeping quality as compared with milk of lower fat content ".

As the majority of Barkworth's samples were derived from dairy farms in the south east of England, it was thought that results for a western area (Mid and West Wales) would be interesting for comparative purposes.

The material for this article was obtained from the results of eighteen County Clean Milk Competitions, and thirty Local Authority Milk Surveys during the six years' period, 1925-30. All samples were examined according to the standardised routine method, morning samples at twenty-eight hours after milking and evening samples at twenty-four hours old (2).

The temperature of the samples on arrival at the laboratory ranged from 50° to 68°F. All samples were brought to 60°F. before testing.

The keeping quality test was carried out at a constant temperature of 60°F., the period of sweetness being calculated according to quarter days, the average keeping quality being calculated in hours according to the " True life " table in the Ministry's " Guide to Clean Milk Competitions " (Third Edition). The " official " milking times were assumed to be 7 a.m. and 4 p.m.

The tables and charts show results from a total of 2,256 samples.

TABLE I.

846 Morning Samples.

Bacterial count per cubic centimetre.	*Under 3% fat.*		*3–4% fat.*		*Over 4% fat.*	
	No. of samples.	*Average K.Q. in hours.*	*No. of samples.*	*Average K.Q. in hours.*	*No. of samples.*	*Average K.Q. in hours.*
0– 1,000	7	109.9	22	95.1	2	95.0
1,001– 5,000	31	92.5	76	93.7	26	92.1
5,001– 10,000	13	84.5	43	88.3	8	92.0
10,001– 30,000	24	78.3	90	83.8	15	88.0
30,001– 50,000	13	85.9	40	79.2	4	79.0
50,001–100,000	14	76.3	48	77.9	10	75.4
100,001–200,000	21	79.4	50	74.9	8	75.6
200,001–500,000	32	71.6	89	68.0	12	80.7
500,001–750,000	13	68.5	61	65.8	7	64.1
Over 750,000	16	62.3	72	60.7	9	53.9
Totals	154		591		101	
			846			

TABLE II.

1,313 Evening Samples.

Bacterial count per cubic centimetre.	*Under 3% fat.*		*3–4% fat.*		*Over 4% fat.*	
	No. of samples.	*Average K.Q. in hours.*	*No. of samples.*	*Average K.Q. in hours.*	*No. of samples.*	*Average K.Q. in hours.*
0– 1,000	3	101.0	68	102.9	105	107.5
1,001– 5,000	17	92.0	156	98.4	177	97.7
5,001– 10,000	2	71.0	78	89.5	69	94.5
10,001– 30,000	4	91.0	101	87.7	101	92.1
30,001– 50,000	6	72.2	32	80.4	38	87.6
50,001–100,000	3	71.7	53	79.7	36	91.2
100,001–200,000	7	71.0	36	83.2	41	82.7
200,001–500,000	4	74.0	47	74.9	49	76.2
500,001–750,000	1	65.0	20	76.6	22	74.8
Over 750,000	1	65.0	13	70.6	23	74.3
Totals	48		604		661	
			1,313			

TABLE III.

2,256 Morning and Evening Samples.

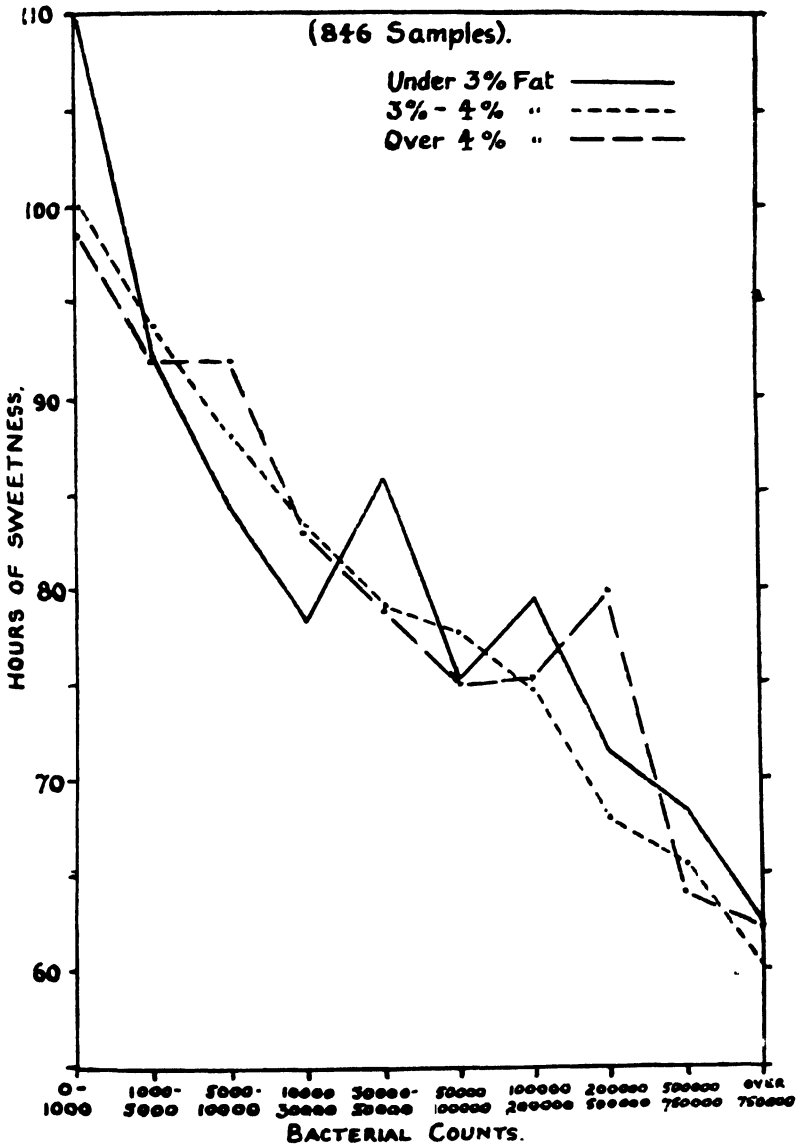
Bacterial count per cubic centimetre.	*Under 3% fat.*		*3–4% fat.*		*Over 4% fat.*	
	No. of samples.	*Average K.Q. in hours.*	*No. of samples.*	*Average K.Q. in hours.*	*No. of samples.*	*Average K.Q. in hours.*
0– 1,000	17	96.8	79	102.6	114	106.0
1,001– 5,000	58	91.1	283	94.9	209	95.6
5,001– 10,000	17	83.7	112	89.5	80	94.3
10,001– 30,000	32	80.8	181	85.8	127	90.6
30,001– 50,000	22	81.7	67	82.3	42	87.6
50,001–100,000	18	75.1	96	79.1	51	88.1
100,001–200,000	27	75.8	80	78.1	52	81.3
200,001–500,000	39	72.9	137	71.3	63	78.4
500,001–750,000	14	67.7	74	67.9	30	72.5
Over 750,000	17	62.4	88	61.5	30	70.6
Totals	261		1,197		798	
			2,256			

The average keeping qualities for the various "count groups" are arranged in three groups of fat content.

The results available for the morning milk samples are very few, especially in the case of over 4 per cent. fat group. Chart I does show, however, a tendency for the milk with under 8 per cent. fat to keep longer than the richer milk.

CHART 1.

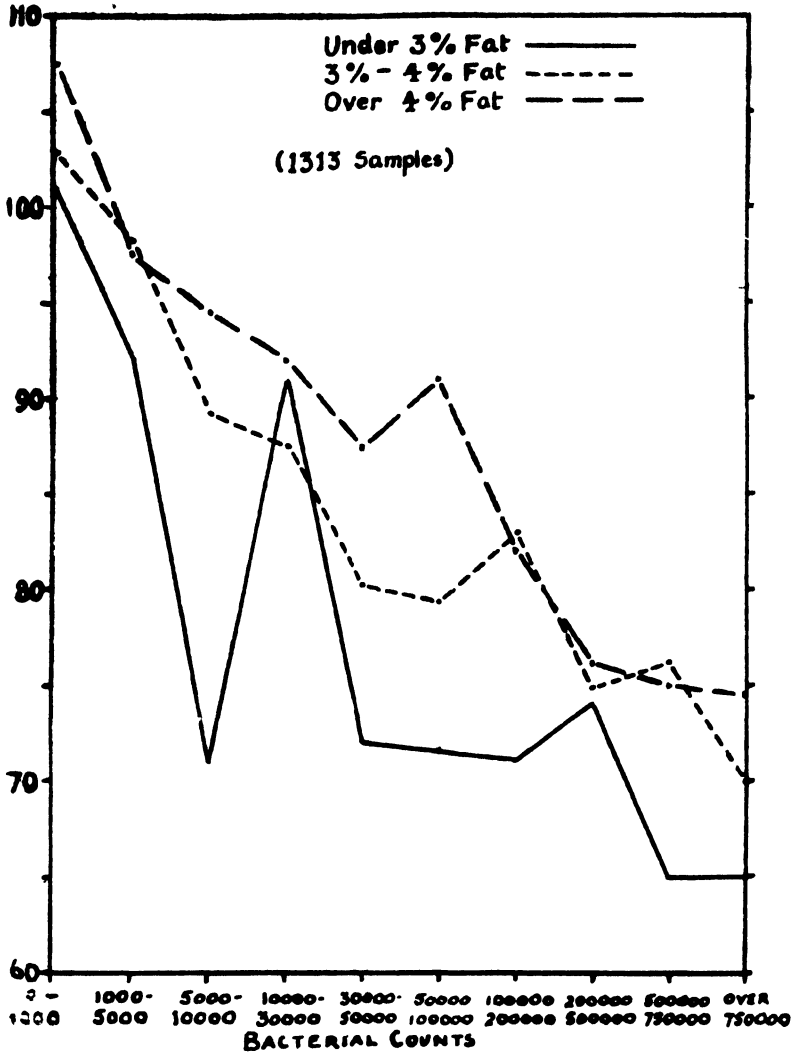
Morning samples.



A study of the evening milk results (Table II and Chart II) shows a lack of data for the under 8 per cent. fat group. In this

CHART 2.

Evening samples.



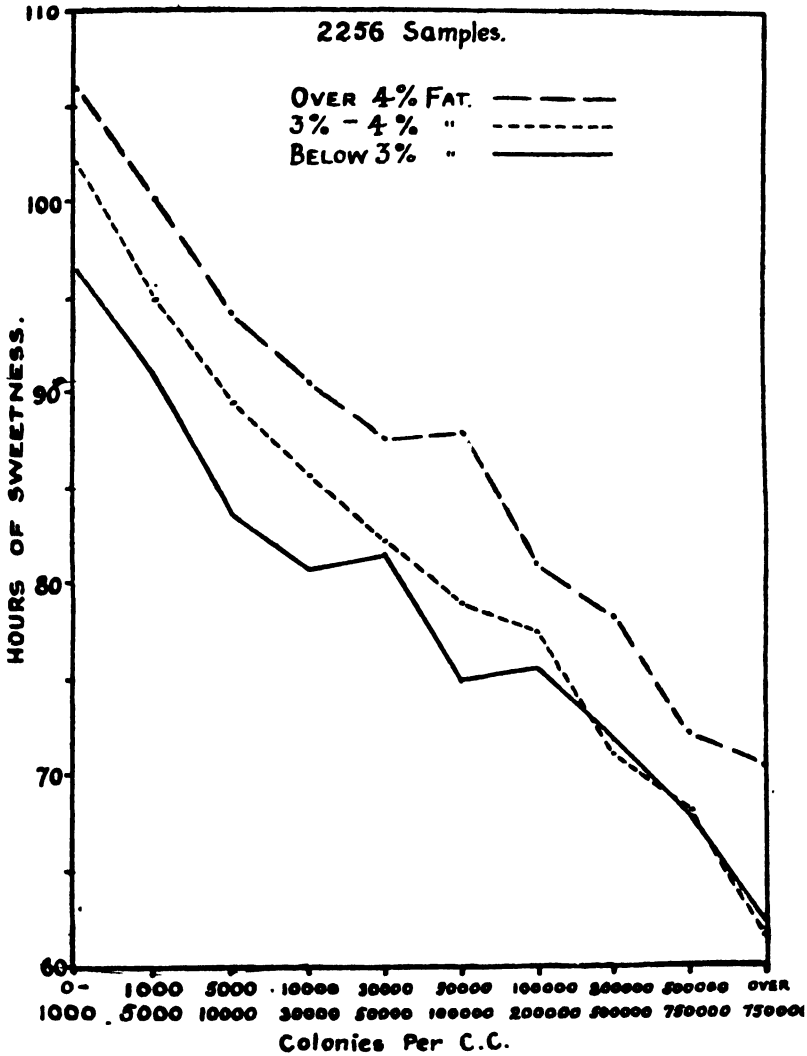
case, however, even if the 8 per cent. group is not considered, the richer milk shows a better keeping quality than the poorer milk.

When the morning and evening samples are taken together, it will be seen (Table III and Chart III) that there is a marked tendency for the rich milk to give a better keeping quality, the milk with over 4 per cent. fat keeping sweet for seven hours longer on the average than the milk with under 8 per cent. fat.

The results taken as a whole show that the problem is worthy of further investigation. It is suggested that samples be allowed

CHART 3.

Morning and evening samples.



to cream and then divided into portions giving varying fat content. This will certainly involve variations in bacterial content, but even so interesting data have been already obtained by this method.

Morning samples from the College Farm were divided into two portions :—

(1) A " poor " milk, with a fat content of 1.5—2.5 per cent.

(2) An exceptionally " rich " milk, with butter fat varying from 7.5—9 per cent.

The bacterial content of the rich milk immediately after division was generally 2—3 times that of the poor milk.

An examination of the keeping quality of forty such duplicate samples shows that :—

(1) The rich milk kept sweet for a quarter day or more longer in twelve cases.

(2) The poor quality milk kept sweet for a longer period in five cases.

(3) The keeping quality was the same in both portions in twenty-three cases.

These results show a tendency for the richer portion to keep sweet for a longer period.

REFERENCES.

1. Barkworth, H. "The influence of the fat-content on the keeping quality of milk". *Journ. Ministry of Agric.*, Vol. XXXVII, pp. 803-6, 1930.

2. "Guide to the Conduct of Clean Milk Competitions". (Third Edition) 1928. *Ministry of Agriculture and Fisheries Miscellaneous Publications*, No. 43.

SEASONAL VARIATIONS IN THE BACTERIAL CONTENT AND KEEPING QUALITY OF MILK.

By S. B. Thomas, M.Sc.,

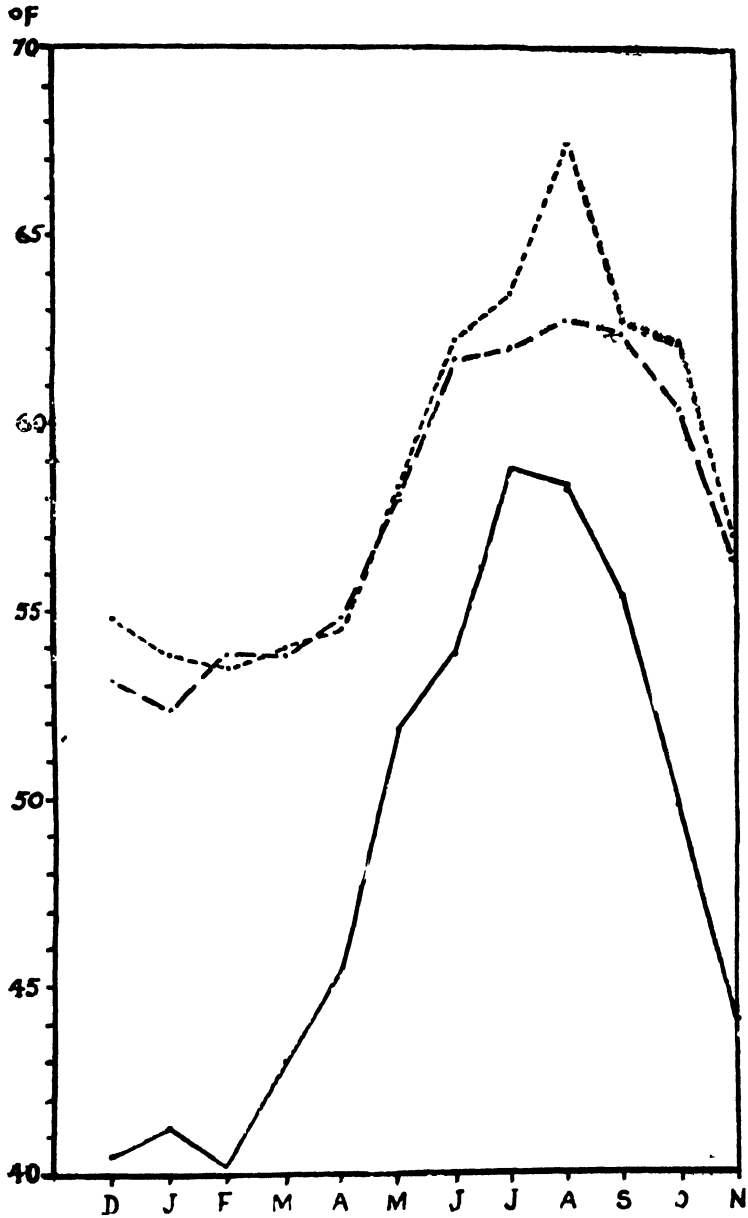
University College, Aberystwyth.

Reference has been made in many of the reports on Clean Milk Competitions to the influence of seasonal factors on the bacterial content and keeping quality of milk.

It is well known that the dominant seasonal factor in this respect is the temperature of the atmosphere.

The seasonal variation in the keeping qualities of average milk was discussed by Freear, Buckley, and Stenhouse Williams in 1919 (1). Later Evans and Davies, in 1926, showed that seasonal variation in temperature has a considerable influence on the bacterial content and keeping quality of samples received during a Clean Milk Competition (2). Barkworth has also summarized the bacteriological results from certain Clean Milk Competitions from this point of view (3), whilst the writer made a similar study of the influence of transit temperatures during 1925-26 (4).

CHART 1.



Average monthly mean maximum and minimum outdoor temp. ———

Average of monthly arrival temperatures for 1,117 afternoon milk samples — — — —

Average of monthly arrival temperatures for 965 morning milk samples - - -

The data used in the present article were collected from the results of routine examinations of milk samples carried out during the past six years at the Dairy Bacteriology Laboratory at Aberystwyth. All the samples were derived from farms in Mid and West Wales; morning milk being examined at twenty-eight hours after milking and evening milk at twenty-four hours.

Comparison of air and milk temperatures.

The figures set out in Tables I and II show the mean monthly air temperatures for a six year period (October, 1924, to September, 1930), taken at the Welsh Plant Breeding Station,[1] and the average monthly temperatures of the milk samples taken immediately on arrival at the laboratory.

A graphical comparison of these temperatures is also given in Chart I.

TABLE I.
Mean Monthly Air Temperatures.
(October, 1924–September, 1930).

	Maximum. °F.	*Minimum.* °F.	*Average Max. and Min.* °F.
December	44.0	37.0	40.5
January	45.4	37.0	41.2
February	44.0	36.1	40.1
March	47.9	38.0	43.0
April	50.8	40.1	45.5
May	59.3	44.5	51.9
June	60.8	47.2	53.8
July	64.2	53.4	58.8
August	63.4	53.4	58.4
September	60.5	50.4	55.5
October	54.5	45.8	49.9
November	48.5	39.9	44.2

An examination of these records shows that :—

1. The average monthly milk temperatures are much higher than the air temperatures during winter and autumn; a difference of from 11° to 15°F. being noticed.

   The air and milk temperatures do not show such a considerable difference during the warmer months (only 5°F. during July and 7°F. during August).

   The mean monthly milk temperatures practically coincide with the maximum air temperatures during the period May to August.

[1] These records were kindly supplied by Mr. Iorwerth Jones, B.Sc., of the Welsh Plant Breeding Station.

TABLE II.

Average monthly temperatures of milk samples on arrival at laboratory.

	Mean temperature. Daily samples.		*Mean temperature. Evening samples.*		*Mean temperature. Morning samples.*	
	°F.	*No. of samples.*	°F.	*No. of samples.*	°F.	*No. of samples.*
December	55.2	76	53.3	54	54.8	59
January	53.1	137	52.4	105	53.8	51
February	54.1	236	53.7	170	53.6	86
March	54.3	308	53.7	162	54.0	109
April	55.0	228	54.8	108	54.7	84
May	58.6	337	58.1	126	58.5	140
June	61.8	258	61.7	80	62.3	128
July	63.5	103	62.0	62	63.5	47
August	65.3	91	62.8	67	67.4	48
September	62.0	83	62.4	52	63.3	67
October	60.8	122	60.4	74	61.3	55
November	57.2	103	56.4	57	57.1	91
Totals		2,082		1,117		965

2. There is an appreciable difference in the arrival temperatures of the morning and evening milk during July and August. This is evidently due to the fact that the morning samples are in course of transit during the day, and the evening's milk during the night.

   It will be found that this factor has quite a marked effect on the keeping quality of the samples.

Seasonal periods.

Bearing the seasonal temperature variations of both atmosphere and milk in mind, it will be seen that the year can be divided into three periods.

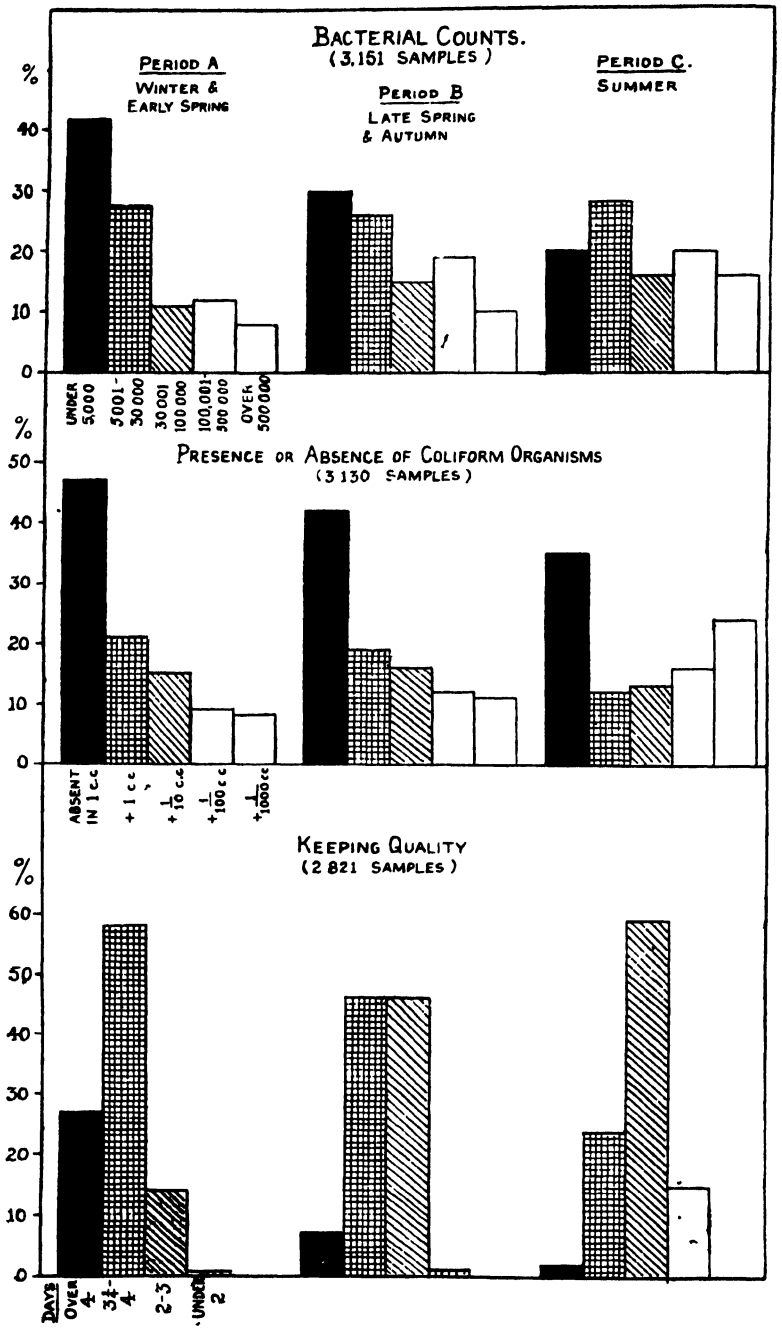
A. Winter and Early Spring.

The cold period, December to April. The mean monthly temperatures of the milk samples are below 56°F. during this period, when the milking cows are kept most of the time in the byres.

B. Late Spring and Autumn.

May, June, and October, November, when mean arrival temperatures recorded varied from 56-61°F. This is composed of two transitional periods.

CHART 2.


BACTERIAL COUNTS.
(3,151 SAMPLES)
PERIOD A
WINTER & EARLY SPRING
PERIOD B
LATE SPRING & AUTUMN
PERIOD C.
SUMMER
%
40
30
20
10
0
UNDER 5000
5001-30 000
30 001 100 000
100,001-300 000
OVER 500 000
PRESENCE OR ABSENCE OF COLIFORM ORGANISMS
(3 130 SAMPLES)
50
ABSENT IN 1 c.c
+ 1 c.c
+ 1/10 c.c
+ 1/100 c.c
+ 1/1000 c.c
KEEPING QUALITY
(2 821 SAMPLES)
60
DAYS
OVER 4
3½-4
2-3
UNDER 2

C. Summer and Early Autumn.

The warm periods, July to September (arrival temperature about 61°F.).

A frequency comparison of the bacterial content and keeping quality of over 3,000 samples arranged according to this seasonal classification is given in Tables III, IV, V, and Chart II.

TABLE III.

Bacterial Count Groups.

Bacterial count per cc.	*Period A.*		*Period B.*		*Period C.*		
	No.	%	*No.*	%	*No.*	%	*Total.*
Under 5,000	605	42	262	30	99	20	1,066
5,001– 30,000	390	27	312	26	134	28	836
30,001–100,000	172	11	185	15	81	16	418
100,001–500,000	169	12	232	19	98	20	499
Over 500,000	115	8	122	10	75	16	312
Totals	1,451	100	1,213	100	487	100	3,151

TABLE IV.

Coliform Organisms Groups.

Presence or absence of coliform organisms.	*Period A.*		*Period B.*		*Period C.*		
	No.	%	*No.*	%	*No.*	%	*Totals.*
Absent	696	47	492	42	165	35	1,353
1 cc.	321	21	220	19	57	12	598
1/10	212	15	190	16	62	13	464
1/100	141	9	144	12	74	16	359
1/1,000	118	8	142	11	111	24	361
Totals	1,488	100	1,178	100	469	100	3,135

A study of these tables and charts shows that :—

1. The bacterial count of the majority of the samples (69 per cent.) taken during winter and early spring are under 30,000 per cubic centimetre.

   Only 48 per cent. of the summer samples attained this standard. Chart II shows the low bacterial count groups dominant during period A, this feature being not so marked in Period B, whilst the groups are fairly even during the summer period.

TABLE V.

Keeping Quality Groups.

Keeping quality at 60°F.	*Period A.*		*Period B.*		*Period C.*		
	No.	%	*No.*	%	*No.*	%	*Totals.*
Over 4 days	378	27.1	74	7	6	2	458
3½–4 days	813	58.4	501	46	85	24	1,399
2 –3 days	200	14.3	490	46	209	59	899
Under 2 days	3	0.2	9	1	53	15	65
Totals	1,394	100	1,074	100	353	100	2,821

2. There is a similar trend in the coliform organism groups, but the difference between Periods A and B is very slight in this case.
3. The seasonal effect is most marked in the keeping quality groups.

A comparison of the keeping quality of morning and evening milk.

It has been already mentioned that samples taken from morning's milk are in transit during the day, and evening's milk samples during the cooler nights.

That this has an effect on the keeping qualities will be seen from a study of Tables VI and VII together with Charts III and IV.

TABLE VI.

Keeping Quality of Morning and Evening Samples.

Bacterial count per cc.	*No. of samples.*	*Av. hrs. sweetness morning samples.*	*No. of samples*	*Av. hrs. sweetness evening samples.*
0– 1,000	31	101.83	176	105.58
1,000– 5,000	133	93.10	350	97.79
5,000– 10,000	114	88.00	149	92.24
10,000– 30,000	165	82.69	206	90.00
30,000– 50,000	57	80.70	101	84.42
50,000–100,000	72	76.61	92	83.91
100,000–200,000	79	76.20	84	81.92
200,000–500,000	133	71.91	100	75.00
500,000–750,000	81	66.06	68	75.41
Over 750,000	97	60.33	37	72.76
Totals	962	—	1,263	—

CHART 3.

Keeping quality of morning and evening samples. (2,225 samples).

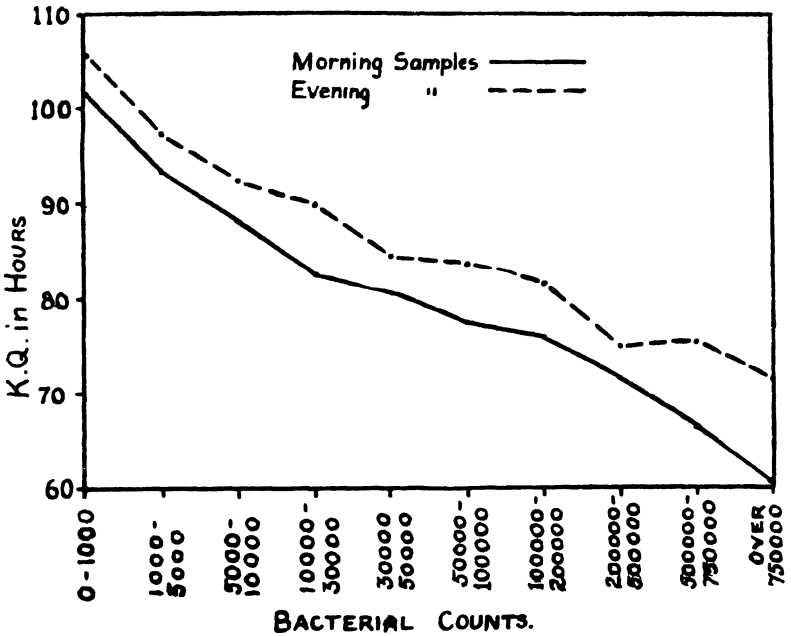


TABLE VII.

Comparison of Keeping Quality of Evening and Morning Milk during Summer.—535 Samples.

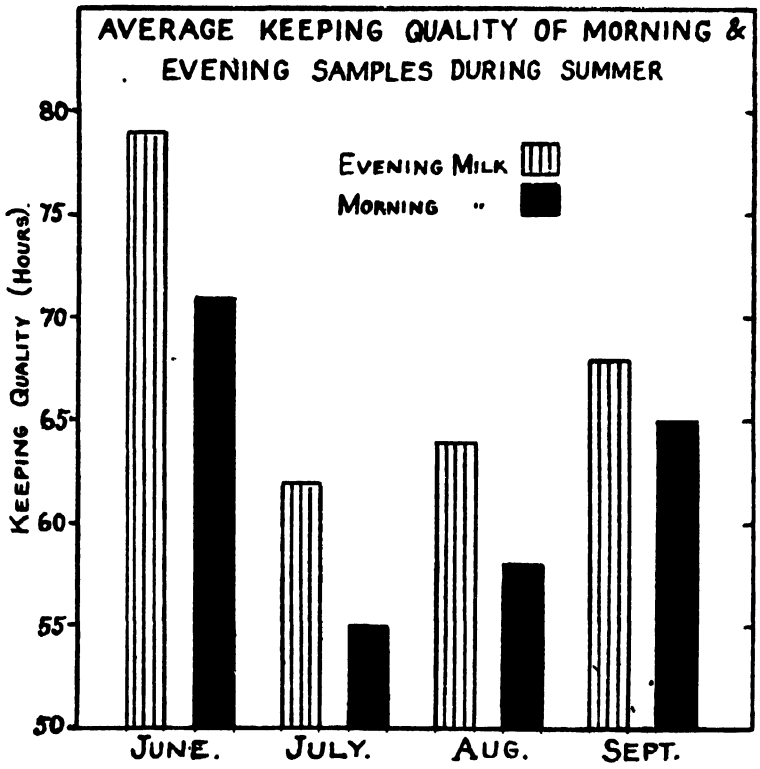
	Evening samples.		*Morning samples.*	
	Mean temp. on arrival.	*Aver. K.Q.*	*Mean temp. on arrival.*	*Aver. K.Q.*
	°F.	hours.	°F.	hours.
June	61.7	79	62.3	71
July	62.0	62	63.5	55
August	62.8	64	67.4	58
September	62.4	68	63.3	65

The graphical representation of 2,225 samples arranged according to bacterial count groups shows that the evening samples keep sweet for three to twelve hours longer than the morning milk.

Chart IV is of especial interest in that it not only shows the longer average keeping quality of evening milk for June, July,

August, and September, but in addition the depressing action of higher temperatures during July and August, the two warmest months of the year.

CHART 4.



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THE "MANY-NECKED" CONDITION OF SWEDES IN RELATION TO VARIETAL AND MANURIAL TRIALS.

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Growers of root crops in North Wales, particularly in 1930, are familiar with the "many-necked" condition (Figs. 3, 4) found during certain seasons in the swede crop. This condition can be produced as was shown by Taylor[1] f.n. (1912) by the swede midge, *Contarinia nasturtii* and again during the present observations 80 per cent of the swedes labelled "midged" when larvae of the midge were present (Fig. 1) subsequently produced the "many-necked" condition. Nevertheless it would be unwise, at present, to attribute all such damage to the depredations of swede midge larvae, for it will be realised that any other insect damage, or even mechanical damage, which removed the terminal bud early during the growing season would lead to the production of several more growing buds with the ultimate "many-necked" condition. It is, however, the "many-necked" condition which causes loss in the swede crop, and any study which has in view the reduction of this loss must consider, primarily, the "many-necked" condition, be its cause single or several. The occurrence of this condition is of seasonal variation —a fact which suggests a biotic rather than a mechanical cause— and not infrequently it is of marked intensity. These seasonal fluctuations render it difficult for the farmer to decide whether or not he should undertake chemical means of control in anticipation of an attack. During a period of agricultural depression it is doubtful whether in North Wales the *normal* attack would justify any considerable annual expenditure on insecticides. Nevertheless, the losses during a season of abnormal infestation when, of course, swedes will be scarce, may be of considerable monetary value, and it was therefore desirable to ascertain whether methods of control other than insecticidal were applicable in the present case. Opportunity was forthcoming through the examination of swedes in the varietal and manurial trials carried out at the College Farm and at other centres in the province.

Observations, 1928.

During 1928 the swedes in the varietal trials at five centres were examined primarily for damage by swede midge larvae. It

[1] T. H. Taylor (1912). "Cabbage Top in Swedes". *Bull. 82*, Univ. Leeds.

was evident that in that particular season the damage caused by the larvae of this insect was mainly that of the charcteristic crumpling of the leaf edges. This resulted in no serious loss to the crop, but the observations were valuable in ascertaining if there was any varietal reaction to the infestation with swede midge. The results of the observations are compiled from three random counts (100 plants each) in each of the varieties of swedes and they are given in Table I.

TABLE I.

Percentage of Swedes damaged by Swede Midge, 1928.

Centre.	*A*	*B*	*C*	*D*	*E*
Variety.	*Madryn.*	*Cefn Leisiog.*	*Faerdre.*	*Mynachdy.*	*Aber.*
Superlative	18.0	18.3	30.0	nil.	21.0
Lord Derby	28.0	25.0	14.6	nil.	18.0
Model	16.6	19.6	25.0	nil.	19.6
Magnum Bonum	32.0	31.0	29.0	nil.	15.3
Danish Bangholm	—	—	27.0	nil.	24.0
Conqueror	12.3	—	—	—	—

It will be seen from Table I that no variety could be claimed to show varietal reaction to the crumpled leaf form of attack by the swede midge larvae, and from these results in conjunction with field observations it would appear that oviposition by the midge is haphazard, and that it is certainly not influenced by the variety of swede.

Observations of 1929.

It was decided to extend the observations of 1928 before accepting the evidence that no selective habit of oviposition was exercised by the swede midge among the different varieties of swedes. Further, the observations of 1928 had indicated that manurial treatment of swedes might influence the ultimate effect of an attack of swede midge on the crop. During season 1929 there was an increase in the " crown attack " by the swede midge hence the results are divided into two; Total attack on crown, leaf, and stem; Crown attack. The results of the infestation of the different varieties at the several centres in 1929 are given in Table II.

It will be seen that there was considerable variation in the infestation of the different varieties at the several centres, and

there was some indication that at these three centres the variety *Superlative* was more liable to attack by swede midge than the other varieties. This was particularly so at Aberkin, where the increased infestation of this variety could be detected on crossing the field. There was no apparent field condition to account for this varietal difference. At the other two centres Superlative showed a heavier infestation, but the figures are not significant.

TABLE II.

Percentage of Swedes damaged by Swede Midge in 1929.

Variety.	*Madryn.*		*Aberkin.*		*Cefn Peraidd.*	
	Total.	Crown.	Total.	Crown.	Total.	Crown.
Superlative ..	39.0	17.0	78.3	56.0	61.3	31.6
Lord Derby .	19.1	7.0	37.6	14.3	58.3	29.0
Model .	31.0	10.0	51.0	27.6	36.3	10.6
Magnum Bonum .	28.0	7.5	63.3	43.0	50.0	22.5
Danish Bangholm	29.0	5.5	51 0	24.0	56.0	21.0
Up-to-Date ...	22.0	4.0	45.0	17.0	53.0	14.0
Northern Farmer ...	20 0	2.5	54.3	31.3	—	—

At Madryn an interesting observation was made on the varieties *Northern Farmer* and *Up-to-date*. The rows of these two varieties happened to pass through a particularly wet area of the field where water had been standing for some time. Counts were taken of each variety in the wet area and again in the drier regions of the field. Northern Farmer gave a count of 42 per cent. " total attack " and 22 per cent. " crown attack " in the wet area as against 20 per cent. " total attack " and 2.5 per cent. " crown attack " in the drier area. Similarly, Up-to-date gave 45 per cent. " total attack " and 38 per cent. " crown attack " in the wet area against 22 per cent. and 4 per cent. respectively in the drier area. It was clear here, as in other instances, that the damage caused by swede midge attack is intensified when growth is retarded. The heavier infestation which is frequently found on the headland appears to be more plausibly explained on these grounds of relatively poor growth rather than that the removal of the terminal buds of swedes by mechanical damage is more common in the headlands.

At two centres an opportunity was afforded for ascertaining the effect of manurial treatment on swede midge attack. Half the swede crop had received artificial manuring (excluding nitrogen) whereas the other half had received farm yard manure. Counts were taken on the " crown attack " alone, and the result is given in Table III.

TABLE III.

Percentage of Swedes showing "crown attack" in Manurial Trials.

Variety.	*Phosphate and Potash.*		*Phosphate and Potash + Farmyard manure.*	
	Centre		*Centre*	
	A	*B*	*A*	*B*
Superlative ...	45.6	27.5	20.0	8.0
Lord Derby ...	56.0	—	18.6	—
Model ...	34.3	31.5	13.0	8.6
Magnum Bonum ..	71.0	—	18.3	—
Up-to-Date ...	32.6	39.3	6.6	7.3
Danish Bangholm .	62.0	—	21.3	—

The superiority of the farm yard manure plots from the point of view of reduction in swede midge attack was very marked, and it was evident that at these centres the improved growth of the swedes due to manurial treatment had helped the swedes to grow away from the attack.

Observations, 1930.

It was decided to extend and elaborate the observations during 1930. This season the damage by swede midge larvae was practically confined to "crown attack" resulting in the "many-necked" condition of the swedes. As it is this form of damage which causes most loss to the swede crop, a study of the "many-necked" condition of swedes in relation to the varietal and manurial trials was undertaken.

Distribution of "many-necked" condition in 1930.

The comparatively heavy infestation of swedes with the "many-necked" condition in 1930 afforded an opportunity for a survey of the distribution in North Wales. The heaviest infestations were recorded along the coasts of Caernarvonshire, and the counts obtained at Aber (Table IV) are representative of this infestation. In the case of the swede midge,[2] Walton (1927) notes that "maximum damage occurred on the lowlands and coastal districts of Caernarvon, the eastern portion of Anglesey and the Conway Valley". At all these districts the infestation with "many-necked" condition was pronounced in 1930, but evidence was forthcoming that it was by no means confined to coastal areas. For instance, 40 per cent. infestation was recorded in two fields at Llanfihangel Glyn-Myfyr (Denbighshire) 25 miles

[2] C. L. Walton (1927). "Some observations on Swede Midge in North Wales". *Journ. Min. Agric.*, Vol. XXXIV, p. 547. September, 1927.

from the coast, in a small inland valley at an altitude of 1,000 feet. Again at Pentrevoelas (Denbighshire) a 25 per cent. infestation was noted in a field 20 miles from the coast at an altitude of 1,100 feet. Few, if any, swedes are grown above 1,100 feet in this province, hence it can be inferred that wherever the swede crop is grown in North Wales it is liable to the " many-necked " condition. In addition to those given in the tables, infestations approximating 30 per cent. were recorded at Moelfre (550 feet), Llanfair T.H. (400), Bettws-y-Coed (60), Pandy Tudur (529), in Denbighshire; Rhoscolyn (60) and Pentraeth (100) in Anglesey; and Aberdaron (50), and Waenfawr (500), and Tremadoc (50), in Caernarvon. At four fields only out of the forty-one well distributed centres visited no specimens of " many-necked " condition were found; these were Llanfair T.H. (600 feet), and Wrexham in Denbighshire and Nannerch and Afon Wen in Flintshire.

Infestation among the different varieties.

During 1930 a more critical investigation of the prevalence of " many-necked " swedes in the different varieties was carried out to ascertain if any varietal resistance occurred. Data at each centre were collected by making six random counts of fifty plants each in each of the several varieties. The results are given in Table IV.

TABLE IV.

Incidence of " many-necked " condition in Swedes, 1930.

Variety.	*Aber.*	*Madryn.*	*Glan-llynau.*	*Cefn Peraidd.**
Superlative ...	39.3 ± 1.89	19.3 ± 1.65	28.0 ± 1.4	2.7 ± 0.5
Lord Derby ...	17.3 ± 2.47	19.0 ± 2.12	30.2 ± 1.2	3.2 ± 1.2
Model ...	58.0 ± 2.02	38.1 ± 2.2	26.8 ± 2.1	4.2 ± 0.15
Magnum Bonum ...	65.3 ± 1.68	46.0 ± 1.58	24.8 ± 2.6	7.75 ± 2.0
Up-to-Date ...	60.3 ± 4.63	25.8 ± 0.43	26.0 ± 1.5	0.2 ± 0.01
Wilhelmsberger ...	60.3 ± 2.38	29.3 ± 2.59	40.0 ± 2.5	3.5 ± 1.2
Danish Bangholm (Studsgart) ...	61.3 ± 2.66	35.6 ± 2.35	34.0 ± 1.4	3.5 ± 0.3

* This centre was the only centre at which a nitrogenous manure had been applied in the drills.

It is apparent, from Table IV, that no variety exhibits a marked resistance to the " many-necked " condition. For instance, *Lord Derby*, which was least attacked at Madryn, was comparatively heavily attacked at Aber and Glanllynau. Again *Magnum Bonum*, which proved to be the most heavily attacked

at three centres, was the least infested at the fourth centre. Thus all varieties varied in their degree of susceptibility to attack at the different centres. Furthermore, in many cases there was no significant difference in the degree of susceptibility among the several varieties at each centre. It is apparent, therefore, that a search must be made outside varietal resistance for a means of reducing the loss due to " many-necked " condition.

TABLE V.

Varietal reaction of Swedes to the " many-necked " condition.

Aber, 17/11/30.

Variety.	*Mean weight of twenty swedes.*		*Difference of mean weights.*	*Weight obtained in Variety Trial Plots.*
	" Healthy."	*" Many-necked."*		
Superlative ...	69.5 ± 1.76 lb.	37.2 ± 2.0 lb.	32.6 ± 3.47 lb.	24½ tons per acre.
Lord Derby ...	64.4 ± 2.07 lb.	41.3 ± 2.45 lb.	23.1 ± 3.21 lb.	19 tons per acre.
Model ...	58.8 ± 2.07 lb.	36.6 ± 0.84 lb.	22.2 ± 2.23 lb.	21⅓ tons per acre.
Up-to-Date ...	55.2 ± 1.47 lb.	37.8 ± 1.61 lb.	17.4 ± 2.27 lb.	19¾ tons per acre.
Wilhelmsberger ...	78.2 ± 2.33 lb.	67.6 ± 2.12 lb.	14.6 ± 3.16 lb.	23¾ tons per acre.
Magnum Bonum ...	48.6 ± 1.36 lb.	37.5 ± 1.12 lb.	11.1 ± 1.73 lb.	18 tons per acre.
Danish Bangholm ...	53.6 ± 2.76 lb.	41.0 ± 2.39 lb.	12.6 ± 3.55 lb.	18 tons per acre.

Reaction of the different varieties to the " many-necked " condition.

Although, as has been shown, there is no evidence of a varietal resistance to attack, field observations seemed to indicate that there was a difference in the manner in which certain

FIG. 1.
Section through young swede damaged by larvae of *Contarinia nasturtii* (*in situ*).

varieties reacted to an attack causing the " many-necked " condition. For example, it was noted that " many-necked " roots of *Superlative* were, in the main, comparatively much smaller than the " many-necked " roots of other varieties, whereas the new variety *Wilhelmsberger* was able to produce quite appreciably large roots despite the " many-necked " condition. It was therefore decided to ascertain if there was a significant reaction of this kind in the different varieties. Two

TABLE VI.

Varietal reaction of Swedes to the " many-necked " condition.

Glanllynau, 31/10/30.

Variety.	" *Healthy.*"	" *Many-necked.*"	*Difference of mean weights.*	*Weight obtained in Variety Trial Plots.*
Superlative ...	69.0 ± 2.83 lb.	36.2 ± 1.76 lb.	32.8 ± 3.47 lb.	27 tons per acre.
Up-to-Date ...	59.6 ± 2.06 lb.	33.8 ± 1.16 lb.	25.8 ± 2.36 lb.	21¾ tons per acre.
Magnum Bonum ...	48.7 ± 1.27 lb.	29.4 ± 1.47 lb.	19.3 ± 2.16 lb.	20¼ tons per acre.
Lord Derby ...	47.2 ± 1.82 lb.	32.8 ± 1.67 lb.	14.4 ± 2.47 lb.	21½ tons per acre.
Model ...	45.4 ± 1.95 lb.	32.0 ± 1.76 lb.	13.4 ± 2.04 lb.	18½ tons per acre.
Wilhelmsberger ...	58.0 ± 1.59 lb.	46.4 ± 1.82 lb.	11.6 ± 2.39 lb.	24½ tons per acre.
Danish Bangholm (Studsgaard) ..	44.2 ± 1.03 lb.	34.0 ± 1.56 lb.	10.2 ± 2.02 lb.	19¼ tons per acre.

centres where the infestation was severe were chosen for this investigation. At each centre, six random lots of twenty " healthy " and of twenty " many-necked " swedes of each variety were taken, cleaned and weighed. The result of the weighings are given in Tables V and VI.

At both centres (Table V and VI) it will be seen that the difference between the mean weights of twenty "' healthy" swedes and twenty " many necked " swedes was greatest in the variety *Superlative* (32.6 lb. and 32.8 lb.). This was supported by observation for the difference in the size of heaps of "healthy" and " many-necked " swedes was much greater in the case of *Superlative* as compared with other varieties. This would indicate that when attacked this variety does not outgrow the attack as well as do the other varieties. When well grown, as was the case at both these centres, the comparatively higher weights of the " healthy " *Superlative* roots, compared with the " healthy " roots of other varieties, say *Magnum Bonum*, tends to counter balance this loss due to the smaller " many-necked " roots. On a farm where the crop is not well grown this reaction factor will however, come into play in reducing the total weight of the crop. The variety *Wilhelmsberger*, on the other hand, showed a comparatively small difference in the mean weights of twenty " healthy " and twenty " many-necked " swedes (14.6 lb. and 11.6 lb.) and it was evident also from the average size of the " many-necked " roots of *Wilhelmsberger* that this variety, although attacked, could produce good sized " many-necked " roots. Similarly the variety *Danish Bangholm* (*Studsgaard*) showed only a small difference in the mean weights of " healthy " and " many-necked " roots, indicating that it was better able to outgrow an attack. The other varieties varied in their reaction to the " many-necked " condition. From the above trials then, it is evident that varieties of swedes differ in reaction to the attack causing the " many-necked " condition. In the above trials *Superlative* suffered most, while *Wilhelmsberger* and *Danish Bangholm* (*Studsgaard*) were least damaged when attacked.

Estimated loss due to " many-necked " condition.

It is also possible, from Tables V and VI, to estimate the loss due to the " many-necked " condition of swedes. The results of the trials at Aber (Table V) will be considered for preference, for in addition to the uniform conditions existing in the variety trial plot at this centre, it is possible to give the rotation and the previous manurial treatment. The swede crop followed oats and vetches, after oats the previous year, which had followed three years grass. The manurial treatment in the rotation consisted of an application of ten tons farm yard manure per acre in autumn, 1928, prior to oats and vetches, and a dressing in autumn, 1929, preceding the present root crop,

FIG. 2.

"Many-necked" swede with bacterial rot commencing from *root*.

while in addition 4 cwt. superphosphate was applied per acre before closing the ridges this spring. The loss is more easily realized when the figures of the average weight of twenty swedes in Table V are converted into tons per acre.[3] Thus the weight of " healthy " swedes of the variety *Superlative* at Aber is equivalent to a crop of 27.4 tons per acre, whereas the " many-necked " swedes of this variety represent a crop weighing 14.6 tons per acre. The variety *Superlative* at Aber had a 40 per cent. infestation with " many-necked " condition, so that such a crop would yield accordingly 22.3 tons per acre (actual weight on entire crop in variety trials was 24½ tons per acre). Hence the loss in this crop due to " many-necked " condition will be the difference between the weight of a " healthy " crop and that with a 40 per cent. infestation. This loss was approximately *5 tons per acre*. Obviously the loss will vary with the degree of infestation and also, as has been shown, it will vary in the different varieties. Nevertheless, some indication of the loss accruing from the " many necked " condition of swedes can be gleaned from Table VII, which has been compiled from Table V. It must be borne in mind, however, that these figures are for a crop of swedes grown under good conditions, and that the loss would be greater when the swedes are poorly grown.

TABLE VII.

Estimated loss due to " many-necked " condition.

Percentage infestation.	*Variety— Superlative.* (Healthy = 27.4 tons p.a.).	*Lord Derby.* (Healthy = 25.3 tons p.a.).	*Wilhelmsberger.* (Healthy = 32. tons p.a.).
10	1¼ tons per acre.	1 ton per acre.	½ ton per acre
20	2½ tons per acre.	1¾ ton per acre.	1¼ ton per acre
40	**5** tons per acre.	3¼ tons per acre.	2¼ tons per acre
50	6 tons per acre.	**4½** tons per acre.	3 tons per acre
60	7¼ tons per acre.	5½ tons per acre.	**3½** tons per acre
70	9 tons per acre.	6½ tons per acre.	4 tons per acre

Bold figures = estimated loss at Aber, 1930.

[3] Each row of swedes was ¾ yard wide, hence each acre is equivalent to 4840 ÷ ¾ × 3 feet of row.

With approximately twenty swedes per 22 feet, the weight of the crop

$$= 4840 \times \frac{4}{3} \times \frac{3}{22} \times \frac{x}{2240} = \frac{11x}{28}$$

tons per acre where x = weight of twenty swedes.

Effect of manurial treatment on incidence of " many-necked " condition.

At three centres where variety trials of swedes were being carried out it was possible to investigate the effect of manurial treatment upon the incidence of " many-necked " condition in swedes. The beneficial effect of nitrogenous manure had been indicated in the observations of 1929. If a nitrogenous manure is given to the swede crop, it is usually applied as a top dressing after singling. At two centres this was the method of application, but it was fortunate that at two of the centres one plot had the nitrogenous dressing applied *in the drills before sowing* and in another plot, *half the nitrate of soda was applied in the drills and half as top dressing.* Counts were taken of the incidence of the " many-necked " condition, and the results are tabulated in Table VIII.

TABLE VIII.

Effect of manurial treatment on " many-necked " condition.

Centre.	*Variety.*	*No Nitrate.*	*n s in drills.*	*½ n s in drills. ½ n s top dressing.*	*Nitrate of soda as top dressing.*
		lb.	lb.	lb.	lb.
Glanllynau	Northern Farmer	43.0 ± 1.9	21.2 ± 1.1	43.1 ± 1.6	—
Cefn Peraidd	Invicta	14.0 ± 1.6	4.5 ± 1.8	9.6 ± 2.1	12.6 ± 3.2
Fyddyn Ysgubboriau	Lord Derby	35.2 ± 2.3	—	—	31.3 ± 1.6
	Danish Bangholm	48.3 ± 2.1	—	—	36.3 ± 2.8

There was not a heavy infestation at Cefn Peraidd, but the incidence was greatest on the " no nitrate " plot (14.0 per cent.). The average infestation on the plot where the nitrate of soda had been applied in the drills was 4.5 per cent. The difference in percentage infestation on the other two plots is not significant, though they indicate a slight reduction from that on the no nitrate plot. The application of 1 cwt. nitrate of soda in the drills did, however, bring about an appreciable reduction in the incidence of " many-necked " condition. At Glanllynau a similar result was obtained despite a heavier infestation with this " many-necked " condition, and the incidence was reduced by a half on the plot where the nitrate had been applied in the drills. Counts on the plot where half was given in the drills and half as top dressing did not indicate any reduction over the no

nitrate plot. At Tyddyn Ysguboriau the root crop was divided into two plots across the entire length of the field, but here the nitrate of soda was applied only as a top dressing to half the field and this was not given until July 2—three weeks after singling. It was obvious at this centre that no appreciable reduction in the infestation had accrued from the application of the top dressing, and it is concluded, in conjunction with other results, that the nitrate was applied at too late a stage in the plants' growth to be of any value in affording an appreciable reduction in the incidence of " many-necked " condition. It is interesting to note that in Table IV, where the incidence of the " many-necked " condition in the different varieties is recorded, that of all centres visited, Cefn Peraidd had the lowest infestation and that this was the only centre where nitrogenous fertilizer (*viz.*, 2½ cwt. sulphate of ammonia per acre) was applied to the varieties in the drill prior to sowing. It is felt that these results afford sufficient evidence to indicate that a reduction in the incidence of " many-necked " condition of swedes can be brought about by a dressing of nitrogenous fertilizer, provided that this is applied at a date sufficiently early to be of service to the plants when the attack is commenced. From these results it appears desirable to apply nitrogenous dressing in the drills before, or when, sowing.

Association of swede midge with disease.

During certain seasons it is frequently noted that " crown attack " by swede midge larvae is followed by bacterial rot. It was thus desirable to ascertain if the swede midge played any direct part in the distribution of the disease (and also of other bacterial or fungal diseases) or whether it was merely that the excavation made by the swede midge larvae in the crown of the swede provided a particularly favourable environment in which bacterial rot could develop. With this object in view, young swedes were labelled " midged " on July 30, when midge larvae were present. Under field conditions, of course, it was impossible to label swedes " not midged ", for one could not be certain that they would not be subsequently attacked. In conjunction with Dr. T. Whitehead, to whom the writer is indebted for assistance in the mycological aspects of this study, the labelled swedes were examined on November 4, 1930, and the results have been compiled in Table IX.

A total of 174 swedes were labelled as " midged ", and 142 of these had produced the " many-necked " condition by November 4th. This would emphasise the relationship of swede midge damage to the " many-necked " condition, but as the

swedes concerned were open to attack by other insects or mechanical damage, the evidence cannot be regarded as conclusive. It will be seen from Table IX that ninety-seven of the "many-necked" swedes were marked as "recovered", which meant that the epidermis had healed up completely (Fig. 4), and save for the several necks, the growth was normal. The remainder (forty-five) of the "many-necked" swedes had failed to outgrow the attack (Fig. 3).

TABLE IX.

Subsequent condition of swedes attacked by swede midge larvae.

Variety.	*Total labelled.*	*Many-necked.*	*Many-necked recovered.*	*One-necked recovered.*	*Bacterial rot.*	*Dryrot.*	*Remarks.*
Magnum Bonum	40	11	17	8	0	0	2 BR from roots
Model	27	4	20	3	1	0	1 BR from split
Lord Derby	38	8	25	5	2	0	1 BR from roots
Superlative	52	15	26	9	6	0	4 BR from roots
Studsgaard	17	4	9	4	0	0	2 BR from side
Total	174	45	97	29	12	0	

Twenty-nine swedes had completely recovered from the attack, and only a single neck was present (Fig. 5) though in most of these cases examination showed the stumped portion of the dead shoots which had not grown. The purpose of labelling the swedes was, however, to see if there was any correlation between "midged" plants and those attacked by bacterial rot and also dry rot. In Table IX it is seen that twelve of the 174 labelled swedes were found to be attacked by bacterial rot, but seven of these had, however, obviously received the initial infestation from the roots (Fig. 2), while in three others the bacterial rot had developed in a split on the side of the root. There was then no evidence to show that swede midge was in any way connected with the distribution of bacterial rot. It should, however, be added that there was not a heavy infestation of bacterial rot on the field concerned this season, but it is felt that there was sufficient to indicate, in the presence of a comparatively heavy infestation with swede midge, whether or not any association between swede midge and bacterial rot existed. Observations made on December 17 would indicate that such an association

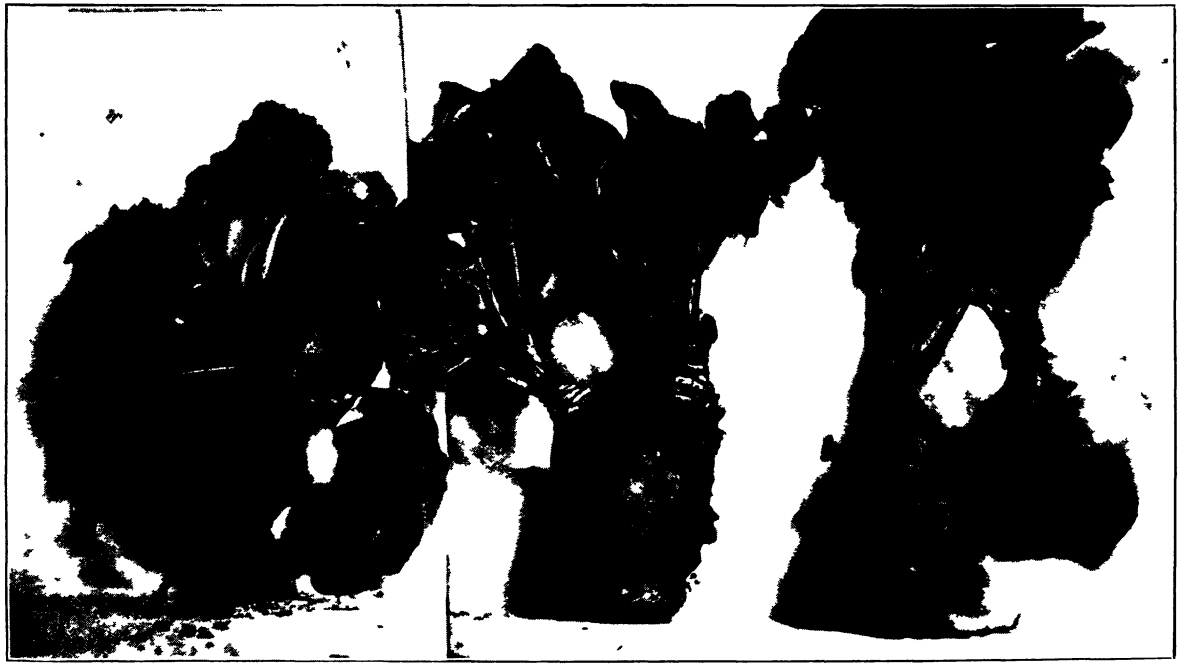

FIG. 3.
" Many-necked " swede
unrecovered

FIG 4
" Many-necked " recovered

FIG. 5
" Single-necked " recovered.

is unlikely, for when 300 swedes which had not been labelled were examined 140 were found to be " many-necked ". Bacterial rot was present in eleven out of the 300 roots, and seven of these roots attacked by bacterial rot were not " many-necked ". It cannot be claimed that the single necked roots had not at one time been attacked by swede midge larvae, but with 140 " many-necked " swedes it would be surprising, if the midge was associated with the distribution of bacterial rot, that more had not been attacked. Hence so far as negative evidence can be accepted as proof these results would indicate that there is no correlation between swede midge attack and bacterial rot.

Not a single root labelled " midged " on July 30th developed dry rot, though in the same area dry rot was not uncommon among the roots which had not been labelled, and of which many showed no sign of damage by swede midge larvae. There was, however, only a slight infestation of swedes with dry rot at this centre, but again, it is felt that with such a general infestation with swede midge any relationship between this insect and dry rot, if existing, would have been apparent.

Acknowledgement is due to Mr. Edwin Jones, M.Sc., for his valuable assistance in the varietal trials at certain centres.

Summary.

(1) The " many-necked " condition of swedes is no uncommon source of loss to farmers in North Wales. In 1930, for instance, it was estimated to be equivalent to 5 tons of swedes per acre in one variety. The condition may be due largely to the depredations of the larvae of the swede midge (*Contarinia nasturtii*, Kieff).

(2) The wide distribution of this condition was shown during a survey in 1930, and an infestation of 30 per cent. " many-necked " swedes was found in a crop 1,000 feet above sea level.

(3) In an investigation initiated to discover a practical means of reducing the loss accruing from the " many-necked " condition, it was found that no significant varietal resistance to attack was evident among the seven varieties under observation.

(4) A difference in the reaction to the " many-necked " condition was shown to exist among some varieties. The variety *Wilhelmsberger* suffered least from attack.

(5) There was a significant reduction in the loss on plots where the swedes had received a dressing of nitrogenous fertiliser, provided this manure was applied sufficiently early for the young plants to benefit from it.

(6) Special observations were made on the relationship of swede midge to disease. Negative evidence indicated that there is no direct relationship between swede midge infestation and the incidence of bacterial rot (*Ps destructans*) and dry rot (*Phoma Lingam*).

EXPLANATION OF PLATES.

FIG. 1. Section through young swede damaged by larvae of Swede Midge (*in situ*).
FIG. 2. " Many-necked " Swede with bacterial rot *commencing from root.*
FIG. 3. " Many-necked " Swede unrecovered.
FIG. 4. " Many-necked " Swede recovered.
FIG. 5. " Single-necked " Swede recovered.

TRIALS ON THE CONTROL OF CERTAIN HORTICULTURAL PESTS IN NORTH WALES.

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During the three years 1928 to 1930 trials have been conducted in the four North Wales counties (Caernarvon, Anglesey, Denbigh, and Flint) with a view to combating certain of the more formidable pests of horticultural crops in the province. These pests have included :—*Psila rosae* (Carrot Fly), *Chortophila brassicae* (Cabbage Root Fly), *Eriophyes ribis* (" Big Bud " of Blackcurrant), and *Trialeurodes vaporariorum* (White Fly). The writer is indebted to the Horticultural Superintendents of the four counties for assistance in certain aspects of these trials.

The Carrot Fly (*Psila rosae*).

The trials on the control of the carrot fly formed part of a scheme of experiments on the control of vegetable root flies carried out by Advisors in Entomology in various parts of England and Wales.

Infestation of Carrot Fly in North Wales.

The growing of carrots on a large scale in North Wales is mainly limited, through the depredations of the carrot fly, to a few local areas such as the west coast of Anglesey and South Caernarvonshire. Elsewhere the success of the crop either fluctuates with the prevalence of this pest or, as in many

PLATE I. CONTROL OF CARROT FLY.

FIG. 1.—Section of treated plot. Rows between white line treated with whizzed Napthalene. (Outside row also treated but not included in plot). Rows to left of lines treated with grass lawn mowings.

instances, all attempts to grow carrots have been given up. Seldom does one meet a grower in this province who has no difficulty in growing carrots, while the reply to enquiry shows that in many districts all attempts to grow this crop have been long abandoned. During the years under observation the general infestation of carrot fly throughout this province has been as follows :—1928, Normal; 1929, First generation attack considerably below normal but followed by a later heavy infestation; 1930, attacks by first generation above normal and second generation attacks slight.

Preliminary Trials, 1928.

In the preliminary trials carried out in 1928 three materials were tested, viz., (1) Creosote and precipitated chalk 1 : 100, (2) Nicotine sulphate (40 per cent. nicotine) and precipitated chalk 1 : 12, and (3) Napthalene (Grade 16). All were applied as light dustings (2 oz. per square yard) and the dressings were given ten days before thinning, at thinning, and ten days after thinning. The trials in 1928 were carried out at three centres, where each material was tested in triplicate.

Centre A (Aber, Caernarvonshire).

An enclosed garden, where within the memory of the gardener all attempts to grow a satisfactory crop of carrots had failed. The soil is a medium garden loam. The procedure of treatment was as follows :—Carrots sown April 24, 1928. First application, May 25; second application, at thinning on June 4, and third application on June 14.

Centre B (Glenydd, Hawarden, Flintshire).

An exposed garden with sandy soil. Carrot fly had been severe for several years. Procedure was as follows :—Carrots sown April 9. First application, May 28; second application at thinning, June 7; third application, June 18.

Centre C (Rhosybol, Anglesey).

Small paddock with light soil. Carrots had failed owing to fly during the last two years.

The results of these preliminary trials have been compiled in averages of the three plots in order to save space and are given in Table I.

It was evident from these preliminary trials that Nicotine sulphate and Creosote had little or no effect in controlling carrot fly damage. On the other hand, the comparative efficiency of Napthalene warranted further extended trials with this insecticide.

TABLE I.

Results of trials of control of carrot fly, 1928.

	Average percentage attack by Psila rosae.					
Centre.	Naphthalene.		Nicotine Sulphate.		Creosote.	
	Treated.	*Control.*	*Treated.*	*Control.*	*Treated.*	*Control.*
A	27.0	100.0	99.3	100.0	100.0	100.0
B	0.6	19.3	14.6	16.6	16.6	15.3
C	No attack.		—			—

Trials of 1929.

Napthalene was the only chemical used in the trials of 1929 and in this case a commercial form, Whizzed Napthalene, was obtained at 15/- per cwt. and applied as previously. In addition, however, an attempt was made to bring about a control of the carrot fly by another chemotropic method. It was realized that the chief effect of Napthalene was that of a repellant, hence trials were carried out to ascertain whether *cut grass lawn mowings* surrounding the plants would suffice to mask the presence of the carrots and hence prevent oviposition. A mulch of cut grass lawn mowings, therefore, was applied to the carrots ten days before thinning, at thinning, and ten days afterwards.

The trials were carried out at four centres during 1929 and the results were as follows :—

TABLE II.

Results of trials on control of carrot fly, 1929.

		Percentage infestation with Psila rosae.							
Centre.	Date.	Naphthalene. Plot				Control. Plot			
		1	2	3	Av.	1	2	3	Av.
A	July 31	0	2	0	6	8	12	8	9.3
	Sept. 20	81	60	68	69.0	88	81	76	79.3
B	Aug. 2	0	0	0	0	2	0	0	0.6
	Sept. 30	61	70	65	65.3	82	64	74	73.3

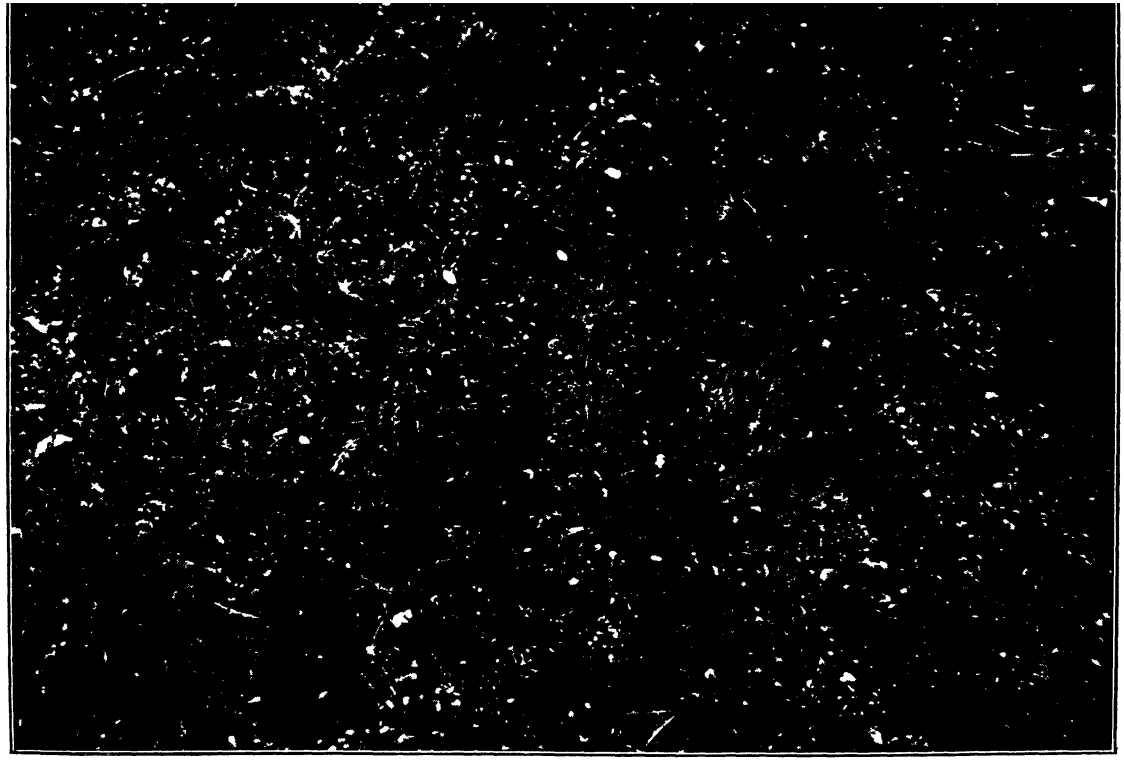

FIG. 2.—Untreated plot in same garden as above.

TABLE II.—Continued.

		Cut grass.					*Control.*				
						Av.					*Av.*
A	July 31	0	0	0	0	0	8	12	8	12	10
	Sept. 20	72	44	72	56	61	81	68	84	76	78
X	Aug. 2	0	6	3		3	0	9	3	—	4
		55	72	65		64	77	62	78	—	72.3

Centres Y and Z, both in Bangor, yielded no attack prior to the third week in August, but when examined on October 3rd all plants on both treated and untreated plots were infested at centre Y, whereas a 75 per cent. infestation was recorded on all plots at centre Z.

It will be seen from the above table that the first generation attack was very slight at all centres, so that there was insufficient data to show the effect of the treatment carried out in June. There was, however, a heavy attack by the larvae of the second generation, but, obviously, the effect of any treatment carried out almost three months previously had been nullified before the second generation appeared. A very slight benefit was found but it was not significant. It would thus appear that in some seasons a second series of dressings would be necessary if the main crop is to be kept free from attack throughout the year. However, in this province it is the early crop of carrots which is desired, because carrots are plentiful and cheap when the main crop has been lifted in districts which do not suffer from the depredations of the carrot fly.

Trials of 1930.

The trials were further extended in 1930, the treatment being confined to Whizzed Napthalene, 2oz. per square yard, and lawn mowings as a mulch. The trials at each centre will be dealt with separately.

Centre A (Aber, as above).

Carrots sown on April 17, and treated June 6, 14, and July 3. Counts were made on September 12, 1930, when the average percentage of plants attacked was obtained by taking five random counts of twenty plants each from treated and untreated plots. The average results were as follows :—

Cut grass, lawn mowings	...	28 per cent. slightly attacked.
Naphthalene ...	...	19 per cent. slightly attacked.
Control	...	100 per cent. severely attacked.

The results, however, are best illustrated by photographs and by weights of plants. Plate 1, Fig. 1, shows a section of the treated plots; to the left of the white line the carrots were treated with cut grass, and between the white lines the carrots were treated with Napthalene. (The row on the right was treated with Napthalene but was not included in counts). Fig. 2 shows a section of the untreated plot where the dead foliage alone indicates the site of the rows. Further, Plate 2 represents the result in a qualitative manner. Fig. 3 is an average bunch of five carrots taken from the cut grass plot; Fig. 4 is an average bunch of five carrots from the Napthalene plot; while in Fig. 5, on the left, is an average bunch of carrots remaining on the untreated plot, and, on the right, the three best carrots from the untreated plot. (It is hardly necessary to add that in Plate 2 the photographs were taken at exactly the same distance from the camera). The value of the treatment is clearly seen in Table III, where the weight of five random samples of ten carrots each (without tops) are given.

TABLE III.

Weights of ten carrots (excluding tops).

Treatment. / *Plot*	*1*	*2*	*3*
Lawn mowings ..	2lb. 8oz.	3lb. 8oz.	3lb. 14oz.
Napthalene ...	3lb. 0oz.	3lb. 1oz.	2lb. 10oz.
Control* ..	0lb. 3oz.	0lb. 2oz.	0lb. 6oz.

Treatment. / *Plot*	*4*	*5*	*Total weight of fifty carrots.*
Lawn mowings ...	3lb. 10oz.	3lb. 1oz.	16lb. 9oz.
Napthalene ...	3lb. 0oz.	2lb. 14oz.	14lb. 9oz.
Control* ...	0lb. 5oz.	0lb. 2oz.	1lb. 2oz.

* Nothing but dead leaves remained of most carrots, so that weights given are of few remaining plants.

Comments.

It was evident from the growth of the plants that, in addition to its chemotropic action, the cut grass had a manurial value, and under moist warm decaying grass growth was stimulated; this is illustrated in the resulting crop. At this centre the carrots were by no means well grown, but they all had the same cultural treatment and the beneficial effect of both dressings is self-evident. In the control plot the majority of the carrots were

PLATE II. CONTROL OF CARROT FLY.

FIG. 3.—Average sample of carrots from plot treated with grass lawn mowings.

completely destroyed, so that the weights represent the best plants on this plot.

Centre Z (College Garden, Bangor).

Open garden with heavy soil, where 75 per cent. carrots were attacked in 1929. Carrots sown on April 23, and treated on June 13, June 24, and July 3.

Counts were made on August 23, 1930, when the average percentage of plants attacked was obtained by taking five random counts of twenty carrots each from the plot. The average result was as follows :—

Control plot ...	...	100 per cent. plants severely attacked.
Napthalene plot	...	20 per cent. plants slightly attacked.
Cut grass ...	...	26 per cent. plants slightly attacked.

The results (Table IV), however, are best illustrated by giving the weight of five random counts of ten carrots (without tops).

TABLE IV.

Weight of ten carrots (excluding tops).

Treatment. / *Plot*	*1*	*2*	*3*
Cut grass ...	1lb. 10½oz.	1lb. 7oz.	1lb. 7oz.
Napthalene ...	0lb. 12 oz.	0lb. 11oz.	0lb. 13oz.
Control ...	0lb. 3 oz.	0lb. 4oz.	0lb. 3oz.

Treatment. / *Plot*	*4*	*5*	*Total weight of fifty carrots.*
Cut grass ...	1lb. 8 oz.	1lb. 7 oz.	7lb. 7½oz.
Napthalene ...	0lb. 10 oz.	0lb. 12 oz.	3lb. 10 oz.
Control ...	0lb. 3½oz.	0lb. 3½oz.	1lb. 0½oz.

Centre Q (Pen-y-bryn, Caernarvon).

This centre was included because it was possible here to test the effect of early thinning along with the Napthalene treatment. The soil was a rich loam. The grower, to whom the writer is indebted for his kind assistance, had failed to grow a satisfactory crop of carrots for a period of over twenty years. Carrots were sown on April 7, 1930, and half the crop was thinned as soon as the plants could be handled, on May 20. The remaining half was thinned on June 20. Treatment of the carrots with Whizzed Napthalene was carried out on June 10,

June 20, and July 1. The infestation with carrot fly on October 1 was as follows :—

Untreated (early thinned)	...	100 per cent. carrots severely attacked.
Untreated (normal thinned)	...	100 per cent. carrots severely attacked.
Napthalene (early thinned)	...	25 per cent. carrots slightly attacked. (marketable).
Napthalene (normal thinned)	...	22 per cent. carrots slightly attacked. (marketable).

Practically all the carrots which showed slight infestation on the Napthalene treated plot were marketable, while the majority were free from attack. The results are more evident when the weights of five random counts, taken on October 1st, of ten plants each from each of the four plots are taken (Table V).

TABLE V.

Weight of ten carrots (without tops).

Treatment.	*Plot*	*1*	*2*	*3*	*4*	*5*	*Total weight of fifty carrots.*
		lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Napthalene (early thinned)		5. 9	4.11	5. 2	4. 9	4. 7	24. 5
Napthalene (normal thinned)		3.11	3. 4	3. 3	3. 8	3. 0	16 10
Untreated (early thinned)		0. 9	0. 9	0. 8	0.10	0. 5	1 0
Untreated (normal thinned)		No plants to weigh.					—

The contrast between treated and untreated plots at this centre was very striking. When visited on October 1, the untreated late thinned plot was quite bare, not a single carrot

being present. On the untreated early thinned plot there was a sparse covering of carrot leaves, but on being lifted the carrots were found to be riddled with damage by carrot fly larvae. The treated plots, on the other hand, stood out in marked contrast, for they were densely covered with foliage. In addition, on lifting it was evident that early thinning had, in this case, produced a heavier crop.

It should be noted that neither at this centre nor at other centres where Napthalene was tried was any damage noticed as the result of the Napthalene.

Summary—Carrot Fly.

(1) Trials in 1928 showed that of the materials used Napthalene was the most promising insecticide for the control of the carrot fly. Three applications as a dust (2oz. per square yard) were given ten days before thinning, at thinning, and ten days after thinning.

(2) Whizzed Napthalene (commercial, obtainable at 12/- per cwt.) was used in 1929 and the results of the previous year were confirmed. A heavy second generation attack, after the effect of the Napthalene treatment had gone, points to the necessity for a second late dressing, in some seasons, if the main crop is to be kept free.

(3) The chemotropic effect of cut grass (lawn mowings) was tested as a means of control for the carrot fly. The carrots were given a mulch of grass at the same periods as with Napthalene. The effectiveness of this treatment was very evident, but in 1929 the late attack confused the results.

(4) The extended trials of 1930 further demonstrated the efficiency of Whizzed Napthalene for the control of carrot fly.

(5) The use of lawn mowings for the control of carrot fly proved to be particularly advantageous, for at all centres where tried a heavier total crop than that obtained on the Napthalene plots was produced.

Cabbage Root Fly (*Chortophila brassicae*).

The trials on the control of the cabbage root fly also formed part of the aforementioned scheme of experiments. The damage caused by this pest in destroying the roots of young brassica plants is well known in the province. It has assumed greater importance in North Wales during recent years owing to a development of growing market garden crops on agricultural

land. During the years under observation, the infestation with cabbage root fly in North Wales has been as follows :—1928. attacks below normal; 1929, infestation normal; 1930, distinctly above normal.

Preliminary Trials, 1928.

In 1928, in accordance with the above mentioned scheme, four separate treatments were tested, viz., (1) Creosote and precipitated chalk 1 : 100 ($\frac{1}{4}$oz. per plant), (2) Chlor-cresylic acid and precipitated chalk 1 : 100 ($\frac{1}{4}$oz. per plant), (3) Napthalene (Grade 16) ($\frac{1}{4}$oz. per plant), and (4) Corrosive Sublimate Soln. (1oz. in 8 galls water—$\frac{1}{4}$ pint per plant). Three applications were given; the first at planting out, the next at ten days after planting, and the last at twenty days after planting. The trials were carried out at three centres: (A) Sealand, Flintshire; (B) Llysfasi, Denbighshire, and (C) Hawarden, Flintshire. At the latter two centres no attack occurred in 1928, hence the results given are confined to one centre, Sealand. At this centre autumn cauliflowers were treated when planting out from the seed bed on June 11 and at two further separate periods of ten days each. The weather was showery during planting; the soil was sandy, and the field was low lying and exposed. Each plot contained 100 plants along a row.

TABLE VI.

Results of the trials on the control of Cabbage Root Fly, 1928.

Treatment.	*Percentage plants attacked.*		
	Examined June 22nd.	*Examined July 3rd.*	*Examined Aug. 24th.*
Creosote and ppted chalk 1 : 100	20	62	No change.
Control .	50	64	No change.
Chlor-cresylic acid and chalk 1 : 100 ..	32	38	No change
Control .	10	60	No change.
Corrosive Sublimate Soln., 1 oz. in 8 gall.	0	12	No change.
Control (watered) ...	36	19	No change.
Napthalene (Grade 16)	15	22	No change.
Control .	56	62	No change.

It will be seen from Table VI that both Corrosive Sublimate Solution and the Napthalene treatment brought about a marked reduction in the number of plants destroyed by cabbage root maggot and thus warranted further trial. The effect of the

FIG. 4.—Average sample of carrots from plot treated with whizzed Napthalene.

treatments with Creosote and also with Chlor-cresylic acid dusts did not reduce the infestation sufficiently to be considered of value in the control of this pest. It was noted at Llysfasi that severe scorching occurred on the Napthalene plot. At this centre transplanting took place on June 22, when the ground was very dry and no rain fell for several days. There was also some wind, and under these conditions the Napthalene collected in the centre of the wilted plant, which subsequently died.

Trials of 1929 and 1930.

Although the trials were conducted at two centres in 1929 and 1930, the attack of cabbage root fly only occurred at the one centre (Talwrn, Anglesey). The results, therefore, are combined in Table VII. The treatments in these trials were confined to (1) Corrosive Sublimate Soln. (as above) and (2) Whizzed Napthalene (also applied as above). The plants used in this case were cauliflowers and were planted out during the third week of May, when the first treatment was given. The plots comprised portion of a sheltered paddock and extended the entire length of the field.

TABLE VII.

Results of trials on the control of Cabbage Root Fly, 1929, 1930.

Treatment.	*Percentage plants attacked.*					
	1929			*1930*		
Plot	*1*	*2*	*Av.*	*1*	*2*	*Av.*
Corrosive Sublimate ...	0	0	0	0	1	0.5
Control (watered) ...	26	28	27	31	23	27
Napthalene (whizzed) ..	4	2	3	6	4	5
Control ...	16	22	19	25	20	22.5

It was very evident in both seasons that the Corrosive Sublimate Soln. was an efficient means of control for the cabbage root maggot, and the grower at this centre was convinced of its superiority over Napthalene for this purpose. There were at this centre several instances of scorching accruing from the Napthalene treatment which cases were not included in the results. The additional value of a non-poison is self-evident and where the use of a poison is undesirable it is clear that Napthalene (whizzed) will give an appreciable control. Care should be taken not to apply the powder on the plant and where possible a very

dry period should be avoided for treatment. During 1930 an opportunity for testing Corrosive Sublimate Soln. under field conditions was forthcoming. A farmer, who had several acres under market garden crops comprising mainly cauliflowers and cabbages, reported severe damage by Cabbage Root Fly to his crops. When visited on June 13 over 50 per cent. of the brassicae were attacked by cabbage root maggot and many had already been transplanted. On June 18 all remaining plants, including some obviously attacked, were treated with Corrosive Sublimate solution. The gaps were also filled with young plants and these treated along with cauliflowers in another row. The farmer reported that none of the treated young plants of the second planting were subsequently attacked, despite the fact that a short row left untreated was severely attacked. Further, many of the obviously attacked plants of the first planting recovered and produced marketable plants. When examined on July 31 it was clear that the latter plants had produced fresh rootlets and made good growth.

Summary—Cabbage Root Fly.

(1) Preliminary trials in 1928 showed that of the four materials tried, Corrosive Sublimate solution (1oz. in eight gallons water—$\frac{1}{4}$ pint per plant) and Whizzed Napthalene ($\frac{1}{4}$oz. per plant) were the most promising of the insecticides tried for the control of cabbage root fly. Three applications were given, viz., at planting, ten days after, and twenty days after planting.

(2) During further trials in 1929 and 1930 confirmatory evidence was obtained concerning the value of these materials as a means of control of this pest. Corrosive Sublimate solution, in these trials, proved superior for this purpose. At one centre, the solution produced a marketable crop from plants which had been attacked before treatment. Instances of scorching as the result of Napthalene treatment were recorded, but these were due to treatment during very dry and windy weather.

" Big Bud ' Mite of Blackcurrant (*Eriophyes ribis*)

Growers of blackcurrants throughout North Wales are very familiar with the damage, known as " Big Bud ", caused by the mite *Eriophyes ribis*. In many districts the pest is the limiting factor in the growing of this useful and profitable crop.

FIG. 5.—(Left) average sample of remaining plants on untreated plot. (Right) three best carrots obtainable on untreated plot.

The use of lime-sulphur spray at winter strength (1 : 12) as a means of control of " Big Bud " was first tried by Lees,[1] and further work by Massee[2] and others[3] at East Malling has emphasised the value of this method of control. In view of the intensity of the infestation of blackcurrants with " Big Bud " mite in North Wales, it was incumbent to carry out trials with lime sulphur. This work was, very naturally, of a demonstrational nature, hence it was only necessary to ascertain whether or not a very definite reduction in the infestation with " Big Bud " was obtainable by means of spraying with lime sulphur under North Wales conditions. Modification of the original scheme became inevitable for various reasons, but it proved possible to carry out the scheme for three years at two centres. The procedure was as follows :—A count was made of the percentage of buds infested with *Eriophyes ribis* on each bush and the figures filed. (After the examination of several bushes it was possible to estimate the percentage infestation to within 10 per cent. by observation and as it was only a very evident variation in infestation that required noting, this method was adopted; a check count was made periodically. In subsequent years counts were made without reference to the previous figures obtained and later the new figures were superimposed upon the previous records. All the bushes were sprayed each year with lime sulphur (1 : 12) at a date as late as possible before the flowers opened. Controls were not kept in the same orchard, because of the close proximity of such untreated bushes to those which had been sprayed. The main purpose of controls in this case was to eliminate factors such as seasonal fluctuation of the pest. In order to do this, observations were made of unsprayed blackcurrant bushes in other gardens in the district.

Centre A (Hawarden, Flintshire).

A plot, outside the walled garden, consisted of 100 blackcurrant bushes of the varieties, Baldwin Black, Black Naples, Lee's Prolific, and Carter Black. The bushes were fourteen years old. The infestation in 1928 is shown in Table VIII and the bushes were sprayed on April 16, 1928; April 19, 1929; and April 16, 1930. Owing to the variation in infestation among the individual bushes, it is necessary to give a full record.

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[1] Lees, A. H. Annual Report Agricultural and Horticultural Research Station, Long Ashton, 1919.

[2] Massee, A. M. Annual Report East Malling Research Station, June, 1926.

[3] Hatton, Amos, and Tydeman. *Journ. Pom.*, Vol. V, p. 124, March, 1926.

From Table VIII it will be seen that after three years' treatment there has been a marked reduction in the percentage infestation with " Big Bud " at this centre. The real effect can only be gleaned by considering each bush. A general indication is obtained, however, when the averages are considered. The average percentage of buds showing the symptoms of " Big Bud " in 1928 was 32.86, whereas in 1931 this had been reduced

TABLE VIII.

Annual record of Big Bud infestation on Blackcurrant Bushes sprayed with lime sulphur.

Bush	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1928	50	20	60	20	20	50	30	30	20	30	30	10	10	10	10	20	20	50
1929	20	5	40	10	10	30	10	20	5	10	20	5	Tr	5	Tr	20	10	20
1931	5	Tr	20	Tr	5	20	Tr	10	Tr	Tr	10	10	Tr	Tr	5	5	5	50

Bush	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1928	20	30	50	60	60	10	10	60	50	20	50	30	10	10	20	20	30	10
1929	10	20	30	20	10	5	Tr	20	10	Tr	10	20	Tr	10	10	Tr	10	Tr
1931	20	20	20	10	10	5	5	10	10	10	20	10	10	10	10	10	10	10

Bush	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
1928	10	50	10	20	10	20	10	40	10	10	20	20	10	60	60	70	50	60
1929	5	10	Tr	10	10	10	10	20	10	10	10	10	10	20	20	20	20	20
1931	10	20	10	10	10	5	10	10	10	10	20	30	20	10	Tr	5	Tr	Tr

Bush	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
1928	50	60	20	30	30	30	20	20	20	60	40	30	30	30	30	30	5	30
1929	20	20	20	20	10	20	10	10	Tr	10	20	10	10	20	20	10	10	20
1931	5	10	5	Tr	5	5	10	5	Tr	5	10	10	5	10	10	10	10	10

Bush	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
1928	30	30	40	40	60	50	60	80	70	60	50	50	60	50	5	50	40	5
1929	10	10	10	10	30	30	20	30	30	20	20	20	30	20	Tr	20	10	Tr
1931	5	10	Tr	10	20	10	10	20	30	Tr	10	10	20	10	5	10	10	10

Bush	91	92	93	94	95	96	97	98	99	100
1928	60	50	40	40	10	40	40	30	20	20
1929	40	20	20	20	Tr	20	10	10	10	10
1931	20	10	10	20	10	5	5	5	10	5

No counts were made in 1930.
Tr=Trace or less than 1%

to 9.8. Four of the hundred sprayed trees showed, in 1931, an increase in the number of buds attacked by the mite, viz., Bushes 48, 49, 72, and 91. In these the initial infestation (1928) was low, and three of them showed a reduction in 1929. Eighty of the bushes showed a decrease in the infestation at the end of three years' treatment, while in the remainder the infestation was constant. It is worthy of note that these bushes, which had yielded so badly during the years prior to treatment, produced 4 cwt. of currants in 1929 and almost a similar weight in 1930. The grower, who carried out the trials at his own expense, is very

well satisfied with the results and has included spraying with lime sulphur as part of the routine for this crop. Observations in several gardens in the same district showed that the reduction in infestation with " Big Bud " was not due to any seasonal fluctuation, for while on young trees the infestation had increased steadily, with a marked increase in 1931, the older trees, with an original heavy infestation, had maintained this infestation, with a definite increase in 1931. This heavier infestation in 1931 has been general on all unsprayed bushes examined throughout North Wales.

Centre B (St. Asaph, Flintshire).

The plot at this centre consisted of thirty bushes enclosed within a wire-netting cage. The varieties included Boskoop Giant and Black Prince, and the bushes were ten years old. The plot was sprayed on April 18, 1928; April 20, 1929; and April 15, 1930.

TABLE IX.

Annual records of Big Bud infestation on Blackcurrant Bushes sprayed with lime sulphur.

Bush	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1928	70	70	50	60	30	30	20	60	20	1	10	10	10	20	40
1929	10	20	10	20	10	10	5	10	10	Tr	30	10	10	20	10
1930	10	10	10	20	5	20	10	10	10	Tr	20	10	Tr	10	10
1931	20	40	30	50	50		30	30	40	20	60	50	50	70	60

Bush	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1928	50	0	5	Tr	10	Tr	5	10	20	Tr	Tr	Tr	Tr	Tr	Tr
1929	20	0	Tr	Tr	Tr	Tr	Tr	Tr	30	Tr	5	Tr	Tr	Tr	Tr
1930	20	0	Tr	Tr	Tr	Tr	Tr	Tr	20	10	Tr	Tr	Tr	Tr	Tr
1931	60	20	30	20	50	50	60	50	60	20	30	40	40	20	5

It will be seen that at this centre in 1928 the first half of the trees showed a heavy infestation with " Big Bud ", but the remaining trees had only a slight infestation. Spraying was carried out in 1928 under ideal spraying conditions and the sulphur remained on the leaves for several weeks. Counts taken in 1929 and 1930 showed a very marked reduction in the infestation on the heavily infested bushes and on the slightly infested bushes there had been no increase. In fact, a reduction was recorded on some of these. In 1931, however, there was a marked increase above the 1930 infestation and twenty-four bushes showed an increase over the infestation of 1928. The general heavier infestation of " Big Bud " mite in 1931 would suggest that conditions were particularly favourable for the distribution of the mite in 1930, but in the present instance it is felt that the

weather conditions following spraying was the chief factor accounting for the failure of the spraying to control the pest. Heavy rain fell during the night after spraying and continued intermittently for several days. In addition, the wire-netting cage caused heavy dripping of water on to the bushes. The combined effect resulted in most of the lime sulphur being washed off the leaves before migration of the mite was general.

Other centres.

Spraying demonstrations with lime sulphur were carried out for one or more seasons at several centres in Anglesey, Caernarvonshire, and Denbighshire, and were followed by an appreciable reduction in the infestation. It was, however, apparent at these centres that to be of value, spraying must be carried out annually. At one centre records were kept for three years and the bushes showed a marked reduction in infestation. In 1930 the bushes were not sprayed in order that any permanent effect of the treatment could be ascertained. In 1931 observations showed that the infestation in most cases had increased above the infestation of 1928.

Summary—" Big Bud " Mite (*Eriophyes ribis*).

(1) The success obtained at Long Ashton and East Malling in controlling *Eriophyes ribis*—the mite causing " Big Bud " of blackcurrants—by spraying with lime sulphur at winter strength prompted demonstrational trials in North Wales.

(2) At one centre a marked reduction in infestation was secured and maintained for three years by annual spraying. At a second centre a reduction was maintained for two years but apparently owing to adverse weather conditions following spraying and a general increase in the distribution of the mite, the initial infestation was exceeded in the final year of these trials.

(3) It was emphasised from other short interval trials that the spraying with lime sulphur must become annual routine if good results are to be expected.

White Fly (*Trialeurodes vaporariorum*).

This pest of glasshouse crops is widely distributed throughout the province and there is little doubt that its distribution is due to and is increased annually by the sale of tomato and other plants infested with the larval or pupal stage of this pest. White fly is more frequently met with in the gardens of large mansions, where gardening, in many instances, is now being commercialised.

Generally speaking, in the newer glasshouses white fly is not common and where it appears it is quickly treated by fumigation with Calcium Cyanide ($\frac{1}{4}$oz. per 1,000 cubic feet). Instances of failure to eradicate new infestations of white fly by fumigation have come to the writer's notice. In each case they have been traced either to the fact that it has not been realized that two fumigations, at least, are necessary at periods chosen to permit all immature stages of the fly to mature after the first fumigation and yet not to permit further egg laying, or else it has been due to incorrect dosage or to non-airtight glasshouses. It is not intended to elaborate upon the methods of fumigation for white fly, but rather to emphasise the value of the recently introduced parasite *Encarsia formosa* as a means of control for this pest. A detailed account of this parasite is given by Speyer.[4]

It has been mentioned that in North Wales the heaviest infestations with white fly are found in greenhouses of the conservatory type, which not infrequently have larger glasshouses attached. Under these conditions fumigation becomes impracticable and the results are uncertain for the plants contained frequently include very many varieties, some of which may be delicate exotic plants. Further, the glasshouse is never empty, but usually contains plants at various stages of growth, many of which, owing to the development in the sale of cut flowers and of wreath making, will be in the flowering stage. The structure of these greenhouses is often such that airtight conditions are unattainable and results from fumigation are disappointing. Even although all these conditions are not met with in the same glasshouse, one or other factor is frequently at work preventing satisfactory fumigation. Under these conditions the value of the parasite *Encarsia formosa* cannot be over-emphasised. During the last three years, through the facilities kindly afforded by the Research and Experimental Station, Cheshunt, the parasite has been introduced into sixteen centres in North Wales. A tour of these centres in 1930 has convinced the writer of the value of this parasite as a means of control of white fly under general glasshouse conditions. At most centres the white fly, which had previously been a source of trouble, had been reduced to such small numbers that it was no longer a serious factor to the grower. It is, of course, not expected that complete eradication will be obtained by biological means, but in conjunction with judicious fumigation such is possible. At the centres visited it was noted that even the growers, many of whom, prior to its introduction, were most sceptical as to the value of such a minute insect, were

[4] Speyer, E. A. *Bull. Ent. Res.*, XVII, pp. 301-8. March, 1927.

now full of praise of the parasite's achievement. Several growers had themselves distributed the parasite to other growers in their district. At one centre only was the result disappointing and here it was traced to be due to the presence of Eucalyptus, upon which the white fly was breeding prolifically, whereas only a slight percentage were parasitised. It is therefore evident that care should be taken, at centres where the parasite is introduced, that plants which favour the white fly and not the parasite are not overlooked without special treatment. An instance of outside migration of the parasite to Eucalyptus was, nevertheless, noted at Bangor, where it had successfully parasitised pupae of white fly on a Eucalyptus plant some several hundred yards from the glasshouse in which the parasite was bred.

The main difficulty with *Encarsia formosa* is that of overwintering, for if care is not taken the parasite will be lost, necessitating re-introduction the following season. Several instances of successful overwintering of this insect have been noticed. In one case the grower, who believed he had lost the parasite, found some parasitised white fly pupae on plants in a glasshouse which had not been heated in winter and had a temperature of about 46°F. He removed these to a box in the heated houses in the spring and successfully hatched out a stock, which when liberated kept the white fly in check throughout the summer. In other cases the growers had transferred infested plants with both white fly and parasite to a warmer house, such as a cucumber house, which was heated all winter. If this slight care of the parasite is taken it is amply rewarded by allowing the parasite to control the white fly before the infestation with white fly becomes heavy.

Summary—White Fly.

(1) *Trialeurodes vaporariorum* is widely distributed in glasshouses in North Wales. Where single or few crops are grown and other conditions permit, control of this pest has been obtained by fumigation with Calcium Cyanide ($\frac{1}{4}$oz. per 1,000 cubic feet). There are many glasshouses where, for several reasons, such treatment is inadvisable and results have been disappointing.

(2) In older glasshouses, where many and varied plants are grown, the value of biological control of white fly with the parasite *Encarsia formosa* cannot be over-emphasised. This parasite has been introduced into sixteen centres in North Wales with considerable success. At one centre only has it failed to produce a satisfactory control. This was due to the presence of Eucalyptus,

upon which few parasitised pupae of white fly were found.

(3) The chief difficulty in this method is overwintering of the parasite. This has been overcome by conveying (if necessary) parasitised plants in the autumn to such heated places as the cucumber house. At one centre the parasite was successfully recovered in the spring from a house which had not been heated during the winter of 1929.

GREY SPECK DISEASE OF OATS.

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Introduction.

A disease of oats, provisionally identified as " haloblight " has appeared annually since 1921 on certain areas of the experimental farm of the Welsh Plant Breeding Station. The symptoms of this disease are very characteristic. The disease occurs generally in comparatively small patches, which are easily seen during the growing season. In early spring when the plants are 4 to 8 ins. high light green spots appear on the leaves. These spots increase in size and the colour gradually changes from light green to buff and later to brown. Spots may coalesce, forming long brown streaks between the leaf veins. (Fig. 4). When this stage is reached the leaf soon dies and hangs loosely around the base of the plant. (Fig. 5). Sometimes a purple or puce coloration is associated with the disease, but this is not a constant or characteristic symptom. These symptoms agree very closely with those of a disease of oats described in many foreign countries as " grey speck " or " grey leaf "; " *hooghalensche* " in Holland, " *Dorrfleckenkrankeit* " in Germany, and the writers are now of the opinion that the disease described in the present paper is identical with it. This conclusion was arrived at following failure to isolate a causative organism, and as a result of other experimental work carried out during the past two seasons. Many varieties of oats suffer severe damage, especially if the weather conditions are unfavourable to growth during the early

part of the season. On the other hand, if conditions are good, affected plants may recover, but the check to growth is reflected in reduced yields at harvest time. Owing to the absence of any knowledge of the behaviour of this disease in this country it was decided to carry out a series of experiments with the object of :—

(1) ascertaining whether our more commonly grown varieties were all equally susceptible,

(2) testing various methods of control.

Occurrence of Grey Speck in Great Britain and other countries.

Grey speck disease of oats has not been recorded in many districts in this country. According to the Ministry of Agriculture and Fisheries Miscellaneous Publication "Fungus and Allied Diseases of Crops," records of the disease were obtained from Cambridge, Leamington, Surrey and Aberystwyth; while during the past few years it has been observed in many districts in Yorkshire. In Mid-Wales only two occurrences have been recorded outside the Plant Breeding Station, one on Dala oats growing at an elevation of 1,000 ft. in Merionethshire and the other on Welsh *strigosa* growing in the same county (6). In both cases only a slight trace of the disease was seen. The disease, therefore, is not very prevalent in this area. In Scotland it is stated by Smith and Anderson (10) to have occurred frequently on oats in trial plots at the Edinburgh and East of Scotland College of Agriculture. In Holland, Germany, Denmark, Norway and Sweden, grey speck is particularly destructive on many agricultural crops, particularly on certain types of alkaline soil.

Historical.

It is beyond the scope of this article to deal with all published papers on the subject, and reference will only be made to those which have a particular bearing on the present investigation.

Åkermann (1) reported the incidence of this disease in relation to oat varieties in Sweden and his observations agree closely with those of Nilsson-Ehle. Fyrus oats was found to be very resistant to grey speck, Pearl and Melog III highly resistant. Victory, Crown and many other varieties not generally grown in this country were moderately susceptible, whilst Ligowo, Golden Rain and Black Tartarian were highly susceptible. Sampson and Davies (7) studying the incidence of the disease (which was then described as haloblight) under field conditions in 1921 found Fulghum oats to be most severely affected, whilst

FIG 1.
Plants of Orion oats affected with grey speck disease. The leaves show the characteristic spotting
Sown 8/4/30. Photographed 17/6/30

FIG. 2.
Portions of plots of Orion oats. Left—treated with manganese sulphate. Right—untreated.
Sown 8/4/30. Photographed 17/6/30.

Bountiful, Irish Tan, Victory, Algerian *Sterilis*, Black Tartarian, Supreme and American Sixty Day were moderately affected. In 1922, Orion, Black Tartarian and Odal were heavily affected, and the disease that year was frequent on Radnorshire sprig, Ceirch-du-bach, Sixty Day, Black Mogul, Golden Rain and Victory.

At Leamington (6), Abundance, Victory and Black Tartarian were slightly affected, but Sandy, Scotch Potato and Great Mogul were highly resistant.

Within the past few years more attention has been given to testing various methods of control. The application of acid manures is now considered to be efficacious since the disease is usually associated with alkaline soils. Hiltner (4) obtained a higher yield of oats by using manganese sulphate and potassium nitrate. Hudig (5) used manganese sulphate at the rate of 50 kg. per hectare with good results. Arrhenius (2, 3) associated the disease with the calcium content of the soil and according to his results sodium nitrate, gypsum and calcium salts favoured the development of the disease, whereas manganese sulphate, sodium chloride and sodium sulphate gave satisfactory control. In his 1924 experiments, manganese sulphate was completely effective. Samuel and Piper (8, 9) in Australia have proved fairly conclusively, by means of pot cultures, that grey speck in oats is due to a deficiency of available manganese in the soil.

Experimental Data.

It will be convenient to deal with the experimental data under three main headings.

I. Resistance of varieties.

This investigation was carried out during 1929 with the object of testing the resistance of certain varieties of oats on land which in the preceding season had carried a badly affected crop. The soil of this area, which is a small portion in one of the cereal breeding enclosures, is a light loam overlying a shaly subsoil. The cropping and manurial treatment of this piece of land in the immediately preceding years was as follows :—

1925. Oats followed by cocksfoot (single plants). Moderate dressing of farmyard manure before planting out seedlings.

1926. Under cocksfoot. No manure.

1927. Under cocksfoot, ammonium sulphate at the rate of 1 cwt. per acre.

1928. Sown under oats. Superphosphate (35 per cent.) at the rate of 3 cwt. per acre. First appearance of grey speck. Crop badly affected.

Eight varieties of oats, Potato, Ceirch-du-bach, Radnorshire Sprig, Victory, Record, Golden Rain II, Black Tartar and Orion, were sown on April 8, 1929, in 5 ft. drills situated 12 in. apart. Each variety was replicated five times. The seed germinated normally and gave a uniform seedling establishment. The first symptom of grey speck appeared approximately five weeks after sowing and on May 28, 1929, considerable spotting was seen on the variety Orion. By June 10, 1929, the disease had developed rapidly and an excellent opportunity was afforded of testing the resistance of the varieties included in the experiment. Marks were given to each replicate according to the amount of disease present, a maximum of 10 indicating a completely susceptible row. The result of these observations is given in Table I.

TABLE I.

Showing data relating to the resistance and susceptibility of different varieties of oats to grey speck—1929. A maximum of ten marks representing a susceptible replication.

Variety.	*Replications.*					*Total.*	*Average of all replications.*
	a	*b*	*c*	*d*	*e*		
Potato ...	0.5	0.5	0.5	0.0	0.5	2.0	0.4
Ceirch-du-bach ...	2.0	1.5	0.5	1.0	1.5	6.5	1.3
Radnorshire Sprig	1.0	1.5	1.5	1.0	1.5	6.5	1.3
Victory ...	2.5	2.5	2.0	2.5	2.5	12.0	2.4
Record ...	3.5	5.5	3.0	4.0	1.5	17.5	3.5
Black Tartar ..	3.5	3.0	6.0	3.0	4.0	19.5	3.9
Golden Rain II ...	1.0	3.0	3.5	5.0	6.0	21.5	4.3
Orion ...	9.0	9.0	8.0	6.5	9.0	41.5	8.3

From the figures in the above table it will be seen that the disease was uniformly distributed throughout the whole area of the experiment. With the exception of replicate "*c*" in the variety Black Tartar, the figures agree very closely within each variety. In the last column the average marks for all the replications are given. The variety Orion, with an average figure of 8.3, proved to be the most susceptible. On the other hand, the resistance of Scotch Potato oats was quite pronounced. Ceirch-du-bach and Radnorshire Sprig were slightly less resistant with an average of 1.3 each. On the basis of this experiment

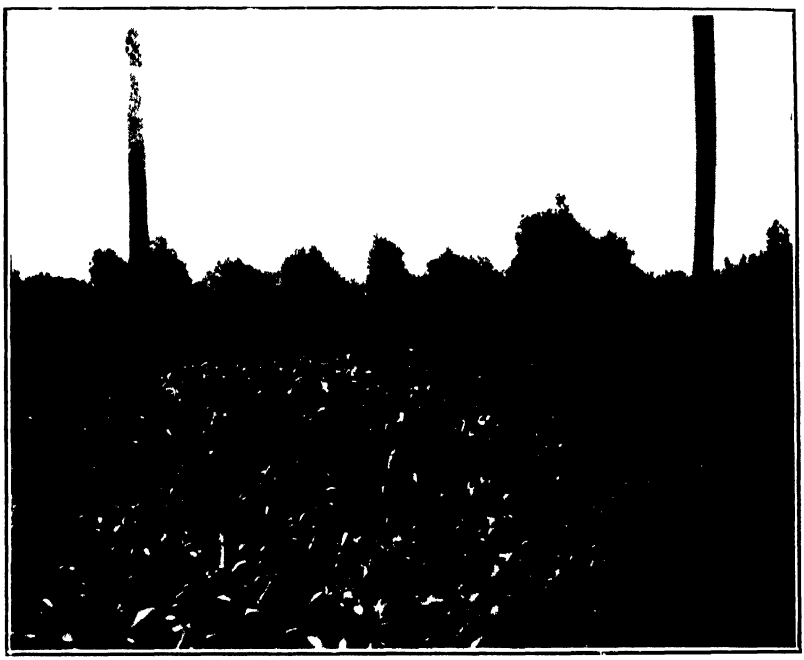


FIG. 3.
Plants of Orion oats showing differences in growth on treated and untreated areas.
Sown 8/4/30. Photographed 17/6/30.

the varieties, in so far as their reaction to grey speck is concerned, may be classified as follows :—

Very resistant :	Scotch Potato.
Moderately resistant :	Cerech-du-bach.
	Radnorshire Sprig.
Moderately susceptible :	Victory.
	Record.
	Black Tartar.
	Golden Rain II.
Very susceptible :	Orion.

These observations agree closely with results of trials of a similar kind carried out in other countries where Orion proved to be highly susceptible and Victory and Black Tartar moderately so.

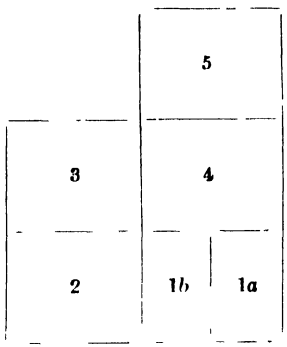
II. Seed transmission.

When these trials were begun in 1929 the disease had not been definitely identified as grey speck, but was provisionally regarded as " haloblight ", a bacterial disease described by Elliot at Wisconsin. Attempts were made to isolate the causative organism *B coronafaciens*, but without success. It was therefore decided to test the possibility of organic infection through the seed. In 1930 an experiment was designed with this object in view. Seed was collected the previous season from both healthy and diseased plants of the variety Orion grown in separate areas. These were sown on April 8, 1930, in large pots filled with soil obtained from well rotted turf taken from an area where cereals had not been recently grown. Altogether twelve pots were used, six sown with seed taken from a healthy crop and the remainder with seed specially collected from badly affected plants. All the seed germinated and grew normally, but no trace of the disease was observed on any of the plants in either series. In this investigation there was no positive evidence of transmission taking place through the seed. In view of the later identification of the disease as grey speck the development of healthy plants from seed removed from diseased parents and grown in clean soil would be anticipated.

III. Control measures.

A considerable amount of data has already been collected in many foreign countries on the control of grey speck and similar diseases of cereals. Many chemicals have been tried but manganese compounds proved to be the most efficacious. It was therefore decided to carry out experiments, using in the first place manganese sulphate. The piece of ground described under

Section I was selected for this purpose. The area was divided into five plots each measuring 8 ft. × 5 ft. and each again divided into eight 5 ft. drills, 12 in. apart. The following is a plan of the experiment.



A weighed quantity of seed of the variety Orion was sown in each drill on April 8, 1930. Three days previous to sowing plots 1a, 2 and 5 each received a dressing of 3.3 oz. manganese sulphate. This was dissolved in two gallons of water and applied over the ground by means of an ordinary watering can. The same dressing was repeated ten days after sowing. Plots 1b, 3 and 4 were left untreated and acted as controls. The total amount of manganese sulphate used represents a dressing of 3-4 cwt. per acre, and appears to be an excessive dose, especially as Samuel in Australia had already shown that a smaller amount would give good results. In the present experiment it was decided to apply a moderately heavy dressing in order to ensure complete control. All the plots germinated normally and brairded well, the second leaf appearing on May 6, and the third on May 16, when the plants were between 4 and 6 in. high. The first signs of the disease were noted on the 5th of June, approximately two months after sowing. At this stage a distinct difference in the appearance of the plots was observed. Treated plots were more forward in growth and possessed healthier and darker green foliage.

In order to obtain some indication of the relative amount of growth made by the treated and untreated crop at the time of the first incidence of the disease, height measurements were taken for each individual 5 ft. row. Similar data were again collected on June 30, when the disease was of general occurrence throughout the whole of the untreated parts of the experiment (Fig. 2, 3). These figures are presented in Table II.

The dates when the heights were measured correspond with the initial and apparent maximum development of the disease,

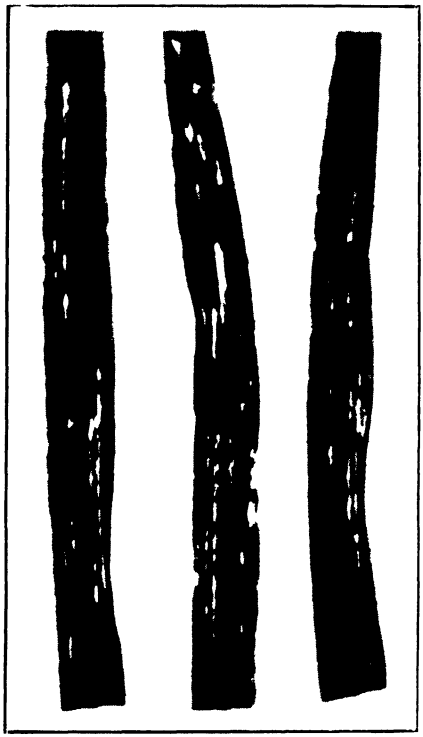


FIG. 4.

Leaves from plants of Orion oats showing characteristic symptoms of grey speck disease.

TABLE II.

Average height in cm. of plants in treated and untreated rows.

	6/6/30	*30/6/30*
Plants in treated rows ...	15.5	38.1
Plants in untreated rows ...	11.5	26.9
Average percent. difference ...	26.6	28.9

the latter coinciding approximately with the beginning of panicle exertion. While the treated plots continued to make healthy and vigorous growth and at no time showed any trace of or tendency to develop the disease most of the foliage of the plants in the untreated plots remained shrivelled and brown in colour. Ripening which occurred about August 1 was decidedly more uniform in the plots which had received manganese sulphate.

All the plots were harvested on August 1 and each row was weighed separately immediately after cutting. The produce of each row was then wrapped in brown paper and suspended inside a greenhouse to dry. Later all lots were again weighed, thrashed separately and grain weights per row determined. These data are presented in Table III.

TABLE III.

Showing average weight of produce per row in grammes.

	Weight 1/8/30 when cut and harvested.	*Weights 6/11/30 after drying in greenhouse.*		
	Total weight.	*Total weight.*	*Grain weight.*	*Straw weight.*
Treated ...	681.0	250.0	61.8	187.2
Untreated ...	391.0	120.9	28.0	92.8
Percentage difference in favour of treatment ...	45.5	52.0	54.6	50.4

From these figures it will be seen that an average increase of produce per row of 45 per cent. was obtained at harvest time as the result of the treatment. This increase was more marked after drying in the greenhouse when the difference was as much as 52 per cent. Further, not only did the treated plots give a higher total dry weight, but they also gave a relatively

higher grain-to-straw ratio inasmuch as the grain weight (column 3) shows an increase of 54.6 per cent. as against an increase in straw of 50.4 per cent.

Further evidence of the superiority of the grain produced on the treated areas is obtained by a study of the relative weights per 1,000 of grain, kernel, and husk, together with percentage husk determinations. The figures relating to this aspect of these investigations are summarised in Table IV.

TABLE IV.

Showing grain, kernel, and husk weights and percentage husk in grain from treated and untreated plots.

	Weight per 1000 grains in grams.	*Weight per 1000 kernels in grams.*	*Weight per 1000 husk in grams.*	*Percentage husk.*
Treated ...	33.20	22.43	10.77	32.45
Untreated ...	29.98	19.58	10.40	34.68
Differences in favour of treatment ...	+3.22	+2.85	+0.37	2.23

It will be seen from columns 2 and 3 of the above table that the untreated plots produce not only lighter grains but also grain of lower kernel weight. The effect of the latter, however, is to give rise to grain of a higher husk percentage as shown in column 5, and consequently, grain of inferior quality.

The difference in husk weights between untreated and treated lots (column 4) show no marked dissimilarity. The small difference of 0.37 is such as might occur through sampling, or it may represent a very small increase in size or thickness in the husk of the treated lot.

It is therefore apparent that the general effect of the disease upon grain production in particular is a lowering of the kernel content and of the general quality of the sample.

Arising out of these investigations it becomes clear that the ultimate differences in yield between treated and untreated plots are due to several causes. Firstly, the treatment itself is seen to have a beneficial effect upon growth previous to the incidence of the disease; secondly, yield is definitely depressed through the development of the disease in the untreated plots; thirdly, the reduction in yield whilst general for both straw and grain is accentuated in the case of grain through the failure of the affected plants to attain to miximum kernel development.

FIG. 5.

Photograph showing the effect of grey speck disease on the growth of Orion oats. Left- healthy plants. Right—diseased plants.

Summary.

(1) Eight varieties of oats commonly grown in this country were studied in connection with their resistance and susceptibility to grey speck disease and were classified as follows :—

Resistant :	Scotch Potato.
Highly resistant :	Radnorshire Sprig.
	Ceirch-du-bach.
Moderately susceptible :	Victory.
	Record.
	Black Tartar.
	Golden Rain II.
Very susceptible :	Orion.

(2) An application of manganese sulphate before and after sowing gave complete control of grey speck disease and was found to have a slightly stimulating effect upon the plants in the early stages of growth.

(3) Experiments on seed transmission gave negative results.

(4) Plants grown on an affected area were found to show marked reduction in yield and a falling-off in ability to produce well-filled grain.

The writers' thanks are due to Professor Stapledon, Director of the Welsh Plant Breeding Station, for facilities in connection with the conduct of these investigations and for his interest in the work; to Dr. Pethybridge, Pathological Laboratories, Harpenden, for copies of some foreign publications, and to Miss Rhoda Jones, B.A., for assistance with literature and publication.

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NOTES ON UNUSUAL PEST OCCURRENCES IN 1930.

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The following is a brief account of three pests which became unusually prevalent in limited areas in South Wales during the summer of 1930. These pests normally occur in relatively small numbers in the area, but in the case of each of them abnormal numbers during this season caused considerable losses in certain localities to the growers concerned. In each case the outbreak was confined to a relatively small area. This would be accounted for in the case of the water cress trouble by the isolation of the beds, which were the only ones in the locality, but with the other two pests referred to neighbouring growers had similar crops which did not show injury.

I. A water-cress pest. (Phaedon cochleariae).

In July, 1930, the writer's attention was called by a large grower in Glamorgan to a serious pest attack on water-cress (*Nasturtium officinale*), which had rendered unsaleable fully half a ton of cress. A visit was paid on July 30 and the beds examined. At this time, beds of about 300 yards in length showed an extremely heavy infestation by adults and larvae of the beetle *Phaedon cochleariae*, both stages of the insect apparently feeding on the foliage of the plants, causing the injury complained of. Many of the leaves had been eaten to such an extent that little but the midribs remained. Much of the cress was obviously too badly damaged to warrant cutting, and the remainder had to be very carefully looked over at the time of washing to ensure the removal of all insects and also to strip off and discard the most severely affected foliage. Cress has been grown for many years in the same beds, but no previous trouble of a serious nature has been met with from this pest.

The adult beetle is about 2½-3½ mm. or about one-eighth of an inch in length; is bright steel-blue in colour and oval and convex in shape. It is described by Fowler (1) as " living on cruciferae; also in marshy places at the roots of grass, in moss, etc. Common and generally distributed throughout the greater part of the kingdom ".

The fully-grown larva of this beetle is about 5 mm., or approximately one-fifth of an inch in length. It has a black head and torpedo-shaped body. On its back (dorsally) there are four tubercles, dark brown in colour, on each of the body segments. Each tubercle bears two stiff bristles. On each side of the insect (laterally) there is a row of more prominent tubercles, paler but with dark patches where the two bristles emerge. There are eight pairs of these, one pair on each of the last eight segments of the body. On the under side there are five rows of smaller dark tubercles, each bearing two stiff bristles. These again are present on the last eight apparent segments. The larva is capable of controlling, apparently at will, the lateral tubercles, and when interfered with will protrude from them, shining, yellow glands. At the date mentioned, July 30, larvae of all sizes were found. There are two overlapping generations of this insect in the year.

Other injury.

In addition to foliage injury, many of the older stems of the plants had numerous holes in them, and on examination these stems were found to be heavily mined by two types of larvae. A few of these were dipterous and appeared to agree with the description given by Taylor (2) of *Hydrellia nasturtii*, Collin. The majority of the larvae, however, were weevil larvae of a species at present undetermined.

Similar infestations.

A similar type of injury is described by Chittenden (3) in America, in this case due to a blackish leaf beetle (*Phaedon aeruginosa, Suffr.*) reported for the first time as injurious to water-cress in Pennsylvania in 1903.

Theobald (4) describes an attack by *P. cochleariae* on red cabbage in 1913, and states that they frequently cause much harm to rape and mustard, particularly in the Fens. *Ph. armoraciae* has been recorded (5) as " in some seasons ravaging entire fields of mustard, cress, cabbage and kohlrabi " in the south-eastern counties of England.

Control.

At the time of inspection, injury appeared to be almost over for the season, and no control measures were undertaken, but

it is hoped that it will be possible to keep this pest under observation next spring, with a view to prevention of injury such as developed this season. On these cress beds, spraying appears to be the only possible line of control to work on. Arsenical sprays as used in America do not appear to be desirable in this country, and sprays of a less poisonous nature, used a considerable time before cutting the cress, will be used.

Chittenden mentions the possibility of flooding the beds, so that the insects would rise to the surface of the water, which when released later would wash many down stream. This method is not practicable in this particular case in Glamorgan, where the flow of water is very sluggish.

II. The Beet Carrion Beetle (Blitophaga (Silpha) opaca).

A severe attack on mangolds by the larvae of the beetle *Blitophaga opaca* occurred on a farm in Monmouthshire in the early summer of 1930. A plot of mangolds three acres in area was affected, and when first visited by the writer on June 16, larvae of this beetle were found to be present to the average extent of six to eight to each plant.

At this time the foliage on many plants had been completely destroyed, nothing but the midribs remaining, and on many others the leaf area had been reduced by fully 50 per cent. Some of the larvae appeared almost fully grown, being nearly half an inch in length. Others were much smaller, and apparently younger, though Curtis (6) suggests in this connection that there may be a variation in size between the two sexes. The larvae are black and shining, rather resembling a wood louse in appearance, but there are, of course, only three pairs of legs, the body being divided into thirteen segments. The third is the widest and the body tapers from this point backwards. Curtis states the larval state to last from approximately June 4 to July 1, after which pupation occurs in the soil and in due course the beetle emerges.

The adult beetle is described by Fowler (1) as "about 10 mm. or four-tenths of an inch in length, oblong oval almost quadrangular in shape, and black in colour, local in England in carcases, moss, etc." His only record for Wales is given as Swansea, but there can be no doubt that it has a much wider distribution than this.

Attacks on mangolds by this beetle were first recorded in 1844, when bad outbreaks took place in France and Ireland. Since then outbreaks have occurred at intervals in the British Isles, but no previous case of severe injury has been met with in South Wales during the last eight years.

Local distribution.

Serious attack by this pest was confined to one farm, the mangold crops on neighbouring farms were very slightly affected, but no other case of injury could be traced, although small numbers of the larvae were observed on fields up to ten miles away.

Control.

At the time of the visit, thinning of the plants had been started, but owing to the prevalence of the pest had been discontinued for fear they would take the whole crop off, the farmer stating that the same insects had completely ruined his mangold crop on a previous occasion about twenty years ago. This delayed singling undoubtedly did much to save the crop.

It was decided to try two methods for the attempted control of the pest :—

1. Making the plants unpalatable by a dressing of soot.
2. Rolling.

The rolling was carried out on June 17. It was noticed that the larvae did not feed so actively during the hotter part of the day, many sheltering in the earth at this time. Consequently the rolling was given in the evening, when most of the insects were on the plants. A light dressing of soot was given the following day.

The treatments appeared very successful. Following their application it was almost impossible to find larvae on the plants, which were then thinned and a satisfactory crop resulted.

III. The Apple Fruit Miner.

The Apple Miner (*Argyresthia conjugella*) is not apparently a common pest in South Wales. No other cases of injury have been met with by the writer in the last eight years. Meyrick (8) describes its occurrence as follows : " Britain to Sutherland, North Ireland common, more local southwards ".

The attention of the writer was called to an orchard where it caused considerable loss to a grower in Monmouthshire during the summer of 1930, a large proportion of the fruit being unsaleable. The grower stated that similar trouble was met with in the summer of 1918, when almost the whole crop was affected. 1928 was another bad year, the fruit in the intervening years being practically clear. Between 1928 and 1929 traces were found on one or two occasions, then again in 1930, fully half the crop was affected.

Some varieties of apples were much more severely affected by this pest than others, in the opinion of the grower infestation being as follows :—

(*a*) *Severely infested*—
Duchess of Oldenburgh,
Irish Peach,
Lord Derby,
Tom Putt,
with two other varieties unknown.

(*b*) *Less severely infested* –
Newton Wonder,
Ecklinville,
Gascoyne Scarlet,
Cox's Orange Pippin,
Bramley Seedling.

The life history of this pest and the injury caused by it have been described by Fryer (7) who, quoting continental authorities, states that " the moth lays her eggs on young apples, also on crab apples, and on Mountain Ash. The resulting caterpillars bore into the flesh of the fruit. The burrows, so called, are usually very winding and twisted, and at first lie not far beneath the skin of the apple. As the caterpillars grow they penetrate further into the flesh and may reach the core, or burrow into the seeds ".

The apples examined on October 28 showed darkened patches on the skin, with a number of minute holes—the entrance places of the caterpillars, whilst on being cut open, the flesh of the fruit was found to have numerous mines--discoloured brown. At this time the caterpillars had left the tunnels. Many of these apparently pupate on the tree, under loose bark, in crevices, etc., where they remain until the following June, the adult moths being on the wing in June and July.

Winter spraying has not, in this case, kept the pest in check. Up to three years ago, caustic wash or a winter wash of Strawsons was used each year. For the last three years Mortegg at 7½ per cent. has been used. In this connection it should be stated, however, that the trees were originally planted far too close, rendering thorough spraying extremely difficult. The present owner is removing many of the trees and cutting back others drastically. The orchard is enclosed and fowls have been kept in it since 1923, which is generally considered likely to reduce considerably fruit pests.

Control.

Apparently winter spraying is the main recommendation which can be made for the control of this pest. The spray should be applied with as much force as possible, whilst, on a small scale, sack banding the trees should enable the grower to collect and destroy a considerable proportion of the overwintering forms of this pest.

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THE POSSIBLE ASSOCIATION OF THE SHEEP NOSTRIL FLY (OESTRUS OVIS) WITH PNEUMONIA IN SHEEP.

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The Sheep Nostril Fly (*Oestrus ovis*) is not usually considered, either academically or agriculturally, as contributing in any noteworthy degree to the rate of ovine mortality. The literature on the parasites dismisses the effects of the larval infestation with the statement that deaths are uncommon. When they are recorded they are described as being accompanied by symptoms of meningitis (false " gid "). While a certain proportion of farmers are acquainted with the " grub in the head ", they do not seem to be aware of what it actually is, or how it came to arrive in that situation.

Some observations of the writer would appear to show that *Oestrus ovis* is responsible for a fairly high percentage of losses among sheep, if not annually, at least comparatively frequently. Before these observations are detailed, it is advisable that a brief summary of the life history of the fly be given.

Summary of the life history of Oestrus ovis.

The adult fly, which superficially resembles a honey bee, is on the wing during the months of July, August, and September. During fine, bright weather, eggs and actual larvae are deposited in the nostrils of sheep, which may be seen attempting to evade attack by keeping their muzzles close to the ground, or by rushing about in a frightened manner.

The larvae immediately begin to wriggle their way up the nasal passages to the sinuses (cavities) in the skull just in front

of the brain. There they attach themselves to the lining membrane, and remain until they are full grown—a period of between eight and ten months. Their length then measures 25 to 30 millimetres, or approximately one inch.

Between the months of April and July the larvae leave the sinuses, and wriggle down the nasal passages, falling or being sneezed out on to the ground, where they bury themselves and pupate. In this state they remain for from three to six weeks, depending on weather conditions. Finally, the fly emerges from the chrysalis and the cycle recommences.

In the light of the above description, the following observations are interesting :—

In May of this year (1930), the writer investigated an outbreak of pneumonia among sheep on a farm in Glamorgan. Fifteen animals had died before the attention of the Department was drawn to the problem. A post-mortem examination was made of one particular animal which, previous to slaughter, showed a profuse muco-purulent nasal discharge, and all the clinical symptoms of pneumonia.

The examination revealed a condition of bronchopneumonia. The trachea contained a large quantity of blood-stained tenacious mucus. In this mucus an Oestrus larva, measuring 25 mm. in length, was found at the bifurcation of the bronchi. Despite its size and brown colour it was difficult to distinguish in the discoloured material in which it was enveloped, and it was as the result of its movements that it was first noticed. Further investigation resulted in the discovery of another larva, 15 mm. in length, which had made its way into a subsidiary bronchus as far as its dimensions would permit, where it lay in a welter of muco-purulence.

No more larvae were found in the bronchi or their divisions, but eight were removed from the frontal sinuses. The remainder of the flock was then rounded up and examined. A number of animals showed a discharge from the nostrils and other symptoms of incipient respiratory trouble, but none was so serious as the case which was slaughtered for post-mortem examination. Instructions were given for attempts at expulsion and eradication of the parasites, but, in spite of all efforts, three more animals died before the end of June. In these cases the pneumonia was definitely septic, and was of the lobar type, involving practically the complete lungs. In none of the three instances were larvae found in the bronchi or lungs, but they were present in the frontal sinuses in the proportions of six, twelve, and fourteen respectively.

Between May and the end of June, six outbreaks of pneumonia similar to the above were investigated on as many widely separated farms in Glamorgan and Monmouthshire. In all twelve post-mortem examinations were made. In seven instances larvae were found in the bronchioles, while, in the remaining five cases none could be discovered in these sites.

It is especially interesting to note that in the latter group the type of pneumonia was lobar and septic (the chief invading organism being apparently *B. pyocyaneus*), whereas, in the case of the group in which larvae were found in the bronchioles, the pneumonia was of the lobular or bronchial type, *i.e.*, not so far advanced.

The measurements of the larvae thus found, excluding those first mentioned, varied from 4 mm. to 10 mm. None approached the dimensions of those first encountered; indeed, had it not been for the experience of the first case, it is quite possible that they might have been overlooked, owing to their pale colour, their small size, their penetration into the smaller bronchioles, and their envelopment in the discoloured tenacious mucus. In every case but one, two larvae were found; in the exception, only one was detected.

The smallest number found in the frontal sinuses was six, the greatest twenty-three. They were present in these sites in every instance whether or not they were discovered in the lungs. In none of the affected flocks were any symptoms of brain trouble noticed, in spite of close observation.

The above discoveries were of particular interest to the writer. In the first place, so far as he has been able to find in the literature on the subject, the presence of the larvae of *Oestrus ovis* in the lungs (*i.e.*, the bronchioles) is a new record. In the second, and more important place, he has periodically encountered outbreaks of ovine pneumonia at this season (May and June) for some years past, without having been able to assign a definite cause. A characteristic feature of the outbreaks was the tendency of the condition to become septic, following bacterial invasion.

Past records were, therefore, consulted, when it was found that while a certain number of cases had occurred every summer since 1923, the years 1926, 1927, and 1930 were notable for the exceptional mortality from this cause. Further reference to records of the Meteorological Office showed that the number of sunshine hours in the area in question, viz., Glamorgan and Monmouthshire, were above normal for the months of July and August—*the months when the adult fly is on the wing*—in the years 1925, 1926, and 1929. The preference of the fly for bright,

sunshiny weather for the deposition of eggs and larvae will be remembered.

In view of the foregoing observations, it is very tempting to allow the wish to become father to the thought, and return a verdict of guilty against the *Oestrus* larva without further parley. Let us, however, give the prisoner at the bar a chance to offer what defence he can.

Arguments for the defence.

In exculpation of the larva it may be argued :—

I. That no larvae had been found in the sites in question previous to this year.

II. That those found this year in such sites were very few in number.

III. That in five cases out of twelve no larvae were found in the lungs.

With the most unbiassed mind possible under the circumstances, one is unable to offer further support to the prisoner.

Arguments for the prosecution.

Let us deal, in the first place, with the above three arguments for the defence, *seriatim* :-

I. The fact that no larvae have previously been recorded in the lungs may be due to lack of observation. As already mentioned, or rather confessed, it was the unexpected discovery of the full grown larva in the first case that put the writer on the track. Another reason, which may also be applied to defence No. III, is that the majority of cases were those of the septic and lobar type of pneumonia, and it is quite possible that the larvae had become involved and destroyed in the inflammatory and septic processes.

II. The fact that so few larvae were found does not preclude the possibility of more having been originally present. In any case, the presence of even one active larva living, feeding, and excreting in the lung would be quite sufficient to set up a pneumonic process under ideal conditions for the eventual development of sepsis.

III. In the five instances in which no larvae were found, the pneumonia was of the lobar and septic type. The probable reason for non-discovery of the parasites has been given above.

In addition to these arguments, the further significant fact may be adduced that all cases of this almost epidemic form of

pneumonia in sheep recorded from 1928 to 1930 have occurred during the critical months of April, May, and June, *when the larvae are migrating to the exterior.* As above recorded, it has been definitely proved that some larvae undoubtedly take the wrong turning and instead of dropping to the ground, pass through the glottis into the trachea and eventually into the bronchi and their ramifications. It is rather difficult to believe that this is the first year in which they began to forsake the straight and narrow way.

In this connection, another theory suggests itself. One has been struck by the variation in the size of the larvae found at the time when, theoretically, they should all be approaching full growth. The life cycle commences with the adult fly emerging from its pupal stage in the month of July, whereas, from cases examined in the middle of the month of June, larvae measuring only 4 mm. have been obtained. Is this the result of paedogenesis (larval reproduction), and an aberration of the migratory instinct on the part of the second larval generation? If so, the position becomes more complicated, as it is of little use attempting to eradicate the parasites by the application of drugs to the upper respiratory passages, if, as the result of paedogenesis, a fresh brood of larvae is taking up its abode in the bronchi and lungs.

In the opinion of the writer, enough evidence has been obtained against the larvae to justify a campaign against the fly. Sheep owners have, therefore, been advised to take measures to protect their flocks against fly attack during the danger months of July, August, and September. These measures consist in placing in the fields where sheep are pastured, large logs or trunks of trees, in each of which several holes, about two inches in diameter, have been bored to a depth of two to three inches. Salt is put in the holes, and the rim of each is smeared with tar, so that, when the sheep attempts to reach the salt, it involuntarily smears its muzzle with the tar, which acts as a deterrent to the fly. The tar must, of course, be frequently renewed and kept fresh and moist.

It will be interesting to see in the coming season what is the result on those farms on which this preventive method has been tried. In the meantime, any farmer who loses sheep from pneumonia in the months of April, May, or June will do himself and his neighbours a service if he will ask his veterinary surgeon to make a special investigation of the respiratory tract, and also the frontal sinuses, with a view to obtaining further information regarding the connection of *Oestrus ovis* larvae with the disease.

A PRELIMINARY NOTE ON THE TREATMENT OF CHRONIC ANAEMIC DEBILITY IN SHEEP BY INOCULATION.

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Progressive debility in sheep is almost invariably ascribed to worms. In many instances these parasites are undoubtedly responsible; but it is the experience of the Department that there exists a type of anaemic debility which is apparently regional or enzootic in character, and which cannot be attributed to such causes.

Animals up to one year old are the usual, but by no means the invariable, victims. Those attacked are always the best in condition, and the pastures involved are those on which the herbage is most luxuriant.

It is not proposed, in this article, to enter into specific details regarding the condition, which is still under investigation, but merely to place on record a small experiment in treatment.

The experiment was the result of an interview with a French Veterinary Surgeon, M. Dutems, of Montargis, in 1928, while the writer was studying the control of animal diseases in France. This gentleman had a considerable reputation as an expert in sheep diseases in his own district in the middle of France, and also, to some extent beyond it, as one first heard of him in Paris.

An interview was arranged, and, in the discussion of sheep diseases generally, it was learned that M. Dutems has had considerable experience of a chronic anaemic condition which appeared to correspond exactly with that encountered by the writer in Wales. No definite cause could be ascertained. Worms and blood parasites had been ruled out by repeated post-mortem examinations.

M. Dutems, however, had decided on a method of treatment based on the hypothesis that, whatever the cause of the condition might be, affected animals had reached such a state of debility and weakness that the body had lost all power of resistance, and that, therefore, the system required a thorough and radical stimulation. This he effected by the inoculation of the serum of an animal (horse) which had been hyperimmunised against anthrax. There was apparently no particular virtue in the serum being specifically anti-anthrax, but one gathered that it was first used because a quantity happened to be available at the time when the idea of carrying out the treatment occurred to M.

Dutems. In a nutshell, his aim was to stimulate the recuperative properties of the body by shock effect, so that they would once more reassert themselves.

According to his account, the treatment was remarkably successful, even in the case of sheep so emaciated as to be considered at death's door. The dose was five cubic centimetres, inoculated subcutaneously in the inner aspect of the thigh. One single dose appeared to be sufficient.

To clinch the argument, M. Dutems offered to conduct the writer to various farms on which the treatment had been successfully carried out, and to allow him to question the farmers freely and without interference. The result of this investigation undoubtedly substantiated the claims made by M. Dutems. Particular emphasis was laid by the farmers on the remarkable effects produced by the inoculation on sheep which, from all accounts, were practically *in extremis*.

In October, 1928, an opportunity occurred of testing the efficacy of the method on a small, and, unfortunately, an unavoidably rough scale in Wales. As the farm on which the experiment was carried out was distant some sixty miles from the laboratory, it was not possible to conduct as scientific a test as one could have wished, a large proportion of the work necessarily devolving on the farmer himself. The only criterion of progress, therefore, under the circumstances, was that of increase or decrease in weight and condition. On these particular premises the past experience of the farmer had been that once a sheep began to go wrong in this manner, the condition was definitely progressive, and, with rare exceptions, ended in death in a state of extreme emaciation. The criterion, therefore, rough though it was, could be relied on to a certain extent.

Needless to say, the fact was first established that one was dealing with the specific condition to which the treatment was applicable. One animal which had died, and two which were specially slaughtered, were examined thoroughly for blood and other parasites. No blood parasites were found, and only a very few worms of the comparatively harmless genus Nematodirus were discovered in the small intestine. Of the dangerous Haemonchus and Ostertagia there were no signs whatever.

The parasitic reconnaissance was rendered remarkably simple by the fact that the stomach and intestines contained very little food; and the almost complete absence of stomach and intestinal worms was most striking. The number of red blood corpuscles was much reduced, and altogether the examination bore out one's previous experience of the condition.

Treatment and results.

On the 30th of October, 1928, eighteen animals in various stages of the condition were picked out. Some were only in the first stages; others were so weak that one felt that the test was hardly fair to the method.

From his previous experience, the owner was convinced that the majority were doomed, unless by the intervention of a miracle, and, with a faith very flattering to the originator of the treatment, was anxious that the whole of the flock should be inoculated. After some discussion, it was eventually arranged to treat the remainder of the flock as controls, and also to pick out three moderately affected cases from the experimental lot.

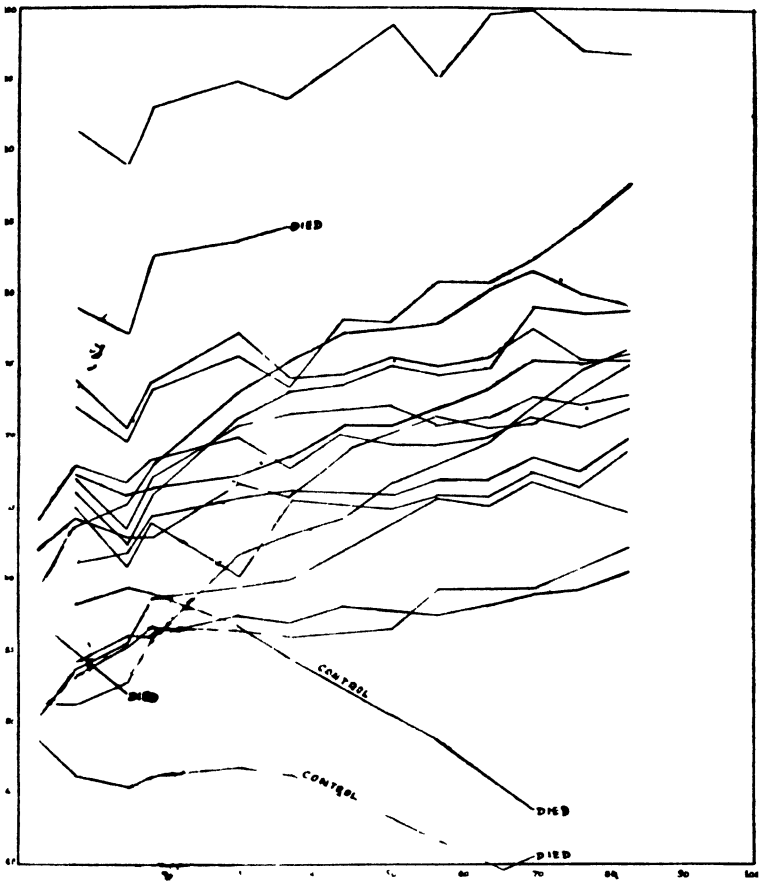
Between the 1st and 7th of November, sixteen animals were inoculated with anti-anthrax serum, obtained from the Pasteur Institute, Paris. The dose in each case was 5 c.c. Previous to inoculation they were weighed. The weights varied from 48 to 92 lb. It should be explained that the 92 lb. sheep was not affected, but was included as a concession to the owner.

The sheep were weighed, as nearly as possible, at weekly intervals, and the weights were recorded graphically. After inoculation, rather more than half showed a distinct set back (anaphylactic reaction), as can be seen by reference to the graph. The set back reached its lowest point on the 7th day, after which a sudden improvement took place. This improvement was maintained, though somewhat haltingly, in every case except the three controls, and one inoculated sheep. This particular animal appeared to be progressing quite well but was found dead one morning, on the thirty-sixth day after inoculation. The three controls died, one on the twelfth, one on the forty-ninth, and one on the fifty-fourth day after the first weighing. All four animals were examined by the writer. Pneumonia was evident in each case. As before, the examination for parasites was practically negative.

It will be noticed from the graph that the three controls, with one exception, took a downward course from the start. The exception showed an almost negligible rise at the commencement, and thereafter a steady decline. Without wishing unduly to favour the experiment, it must be observed that the case of the inoculated animal which was found dead gave the impression of pneumonia resulting from a sudden chill, rather than the sequel of the last stages of debility. The animal in question was one of the most hopeful cases, weighing 79 lb. in the first instance. Its position in the graph is second from the top. In contra-distinction to the 92 lb. animal at the top of the graph, it was definitely

affected, though only in the commencing stage. Nevertheless, as can be seen from the graph, it was making distinct progress.

The experiment was continued for a period of three months. During that time six animals died in the uninoculated flock. The owner, who had not expected to save any of the members of



Chronic anaemia of sheep.—Experimental inoculation.

the experimental lot, was decidedly impressed with the results, which, considering the rough and ready nature of the test. were certainly somewhat encouraging.

It was not intended to publish anything on the subject until the treatment of a large number of affected flocks had placed the value of the method beyond doubt, one way or the other. Pressure of other work and other circumstances have, however, combined to delay this ideal, but it is hoped, as soon as time and opportunities permit, to carry out experiments on a more extensive scale, with more adequate controls and closer scientific supervision.

ABSTRACTS, REVIEWS, AND BIBLIOGRAPHICAL NOTES.

AGRICULTURAL ECONOMICS.

Abstractors:
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ACCOUNTS AND COSTS.

Cost-Accounting; A word for

JAMES WYLLIE. *J. Proc. Agric. Econ. Society*, Vol. 1, No. 3.

It appears to the present abstractor that any summary of this paper would present insuperable difficulties, but that attention should be drawn to it. There is much play of criticism upon both rigid cost accounting enthusiasts and those who perhaps have tended to attach too little value to cost accounting as a method of research in agricultural economics. If in parts it is difficult to know whether the author is merely stating a case or stating professional convictions, he should be given the benefit of the doubt. The plea is undoubtedly for more general use of cost accounts, for study of methods in relation to circumstances and uses, and definitely for their use in economic advisory work. But "there is not much doubt that it is 'enterprise' cost accounts rather than 'complete' cost accounts for which there is a real demand amongst those farmers who have ever given the matter serious attention". A.W.A.

Financial Results: General Report on Six Years.

Report No. 8. Investigations into Farming Costs, etc. JAMES WYLLIE, S.E. Agric. Coll., Wye, Kent.

The results obtained from the financial accounts of twenty-five farms covering 104 farming years between Michaelmas, 1923, and Michaelmas, 1929, and the technique of investigational work of this kind are discussed.

The following is a summary of the general results.

Average size of farm 265 acres.

	Per Farm.	Per Acre.
Average capital invested ...	£5,240	£19 15 5

	Gross.	*Per acre per annum.*	*Percentage on capital per annum.*
	£	£ s. d.	%
Expenditure ...	390,347	14 3 9	
Income ...	382,925	13 18 4	
Deficit ...	7,422	5 5	
Increase in valuations	2,445	1 9	
Net loss ...	4,977	3 8	0.91

When the sum of £2,174, which has been allowed to the farmer for his manual labour is deducted, then the loss becomes £2,803 or 2/- per acre. By charging 5 per cent. per annum interest on capital and deducting the amount paid for the work done by the farmer, the farmer's labour income becomes *minus* 21s. 10d. per acre per annum.

It appears that the capital invested per acre was influenced more by the number and class of livestock kept than by the size of the farm or the percentage of arable land and that no definte connection could be traced between the rate of turnover of farming capital and the net financial result. The author emphasises the need for careful classification of farms before comparison can be made regarding managerial efficiency, and suggests that what the individual farmer needs most of all is some system of recording internal farm transactions in such a way as to be able to test his efficiency for himself. Further, that financial accounting can never be as useful to the individual farmer in testing his efficiency as the keeping of records such as time-sheets, foodstuffs records, yield records, etc. The Report contains a number of tabular statements dealing with the financial results for these farms.

J.P.H.

Financial Accounts: Analysis of Four Years

C. V. Dawe, Agricultural Advisory Department, University of Bristol, 1930.

This is a study of the financial results of twenty-five farms in Wiltshire during the years 1925-28. The farms range in size from less than 100 acres to over 2,500, the average size being 1,094. A classification of the farms show that they range from all grass holdings to holdings with 74 per cent. of arable land, and milk appears to be the chief source of income on the majority of them. On an average the capital invested was £977 per 100 acres. Of this about 57 per cent. was represented by livestock, 29 per cent. by produce and tillages and

	5 most profitable farms. (4 years' average).	*5 most unprofitable farms. (4 years' average).*
Average size ...	1,473 acres.	902 acres.
	Per 100 acres.	Per 100 acres.
Total capital ...	1,000	1,056
Total output ...	652	584
Total costs ...	566	648
Profit ...	86	
Loss ...		64
Profit—per cent. of capital ...	8.6 %	
Loss—per cent. of capital ...		6.1 %

14 per cent. by implements. Between 1925 and 1928 there has been a considerable decrease in the amounts invested in these three types of capital. Livestock have fallen by 18 per cent., produce by 15 per cent., and implements by 6 per cent. The average output for the four years was £615, and average costs of production £593 per 100 acres. The

report does not indicate that success lies in any particular system of farming, but an analysis of the five most profitable and the five most unprofitable farms gives the following results.

The average size of the profitable farms is two-thirds greater than the unprofitable ones, and a smaller proportion of the holdings were under the plough—28 per cent. as against 42 per cent. On an output basis, the profitable farms had an output 12 per cent. greater than the unprofitable farms. The output of livestock from the profitable farms amounted to £465 per 100 acres and was 25 per cent. greater than that from the unprofitable holdings.

The chief difference, however, lies in the costs of production—particularly labour. For every £100 spent on wages the successful farms obtained £386 of output, while the unsuccessful only obtained £256. As regards foodstuffs the unprofitable farms were spending £161 and obtaining an output of livestock of £270, while the profitable farms are spending £170 and obtaining an output of £465.

Attention is drawn to the greater proportion of arable land under cereals on the unprofitable farm and to the question whether these farms would not have shown better results had they fed more of their arable crops instead of selling them. J.P.H.

Pig Keeping: Costs and Financial Results for Six Years

Report No. 9. Investigation into Farming Costs, etc. JAMES WYLLIE, S.E. Agric. Coll., Wye, Kent.

This report deals with the results obtained from pig-keeping on seventeen farms during the period 1923 to 1929. Two outstanding factors appear to determine the net financial result in pig-keeping—the price level of pig meals and the price level of porkers, baconers and stores. To ensure a gross return of about 15 per cent. per annum on the invested capital, the price of porkers and baconers would have to be about 12s. 6d. or 13s. 6d. per stone of 14 lbs. and the price of pig meals from £8 to £9 per ton with eight to twelve weeks' old stores at about 34s. per head.

During the whole period, the loss on pig-keeping on these seventeen farms amounted to £2,938, which is equivalent to about 21 per cent. per annum on the capital invested in pigs and pig equipment. This loss does not include any charges for interest on capital or managerial salaries. Only in the year 1925-26, when prices of pigs were comparatively high and the price of pig meal comparatively low were profits consistently shown. On an average, cost of feed accounted for about 77 per cent. of the total expenses on pigs, while the receipts for pigs sold formed about 92 per cent. of the total income.

Brief notes are given on the different farms included in the investigation and detailed results are given for four typical farms and attention is drawn to the need for a more detailed investigation into pig feeding, with a view to laying down standards by which the pig keeper might measure his efficiency at various points. J.P.H.

Sheep Breeding and Feeding over Six Years

Report No. 10. Investigations into Farming Costs, etc. JAMES WYLLIE S.E. Agric. Coll., Wye, Kent.

Report No. 10 deals with the results obtained from sheep on sixteen farms from Michaelmas, 1923, to 1929. Excluding interest on capital

or managerial salary, there was an average loss per farm per annum of £91 or about 9½ per cent. per annum on the capital invested. Of the total receipts about 87 per cent. came from the sale of sheep and 13 per cent. from wool. Of expenses, about 72 per cent. was for foodstuffs, 20 per cent. for labour and 8 per cent. for other items. On an average every £100 of gross output required an expenditure of £83 on foods, £27 on labour and £8 on other items, with the result that there was a loss of £18 on every £100 of sheep and wool sold. Detailed results are given for six farms where the flocks are kept partly on arable land and for six farms where the flocks are kept mainly on pastures. Owing to the high feeding and labour costs the results from the folding farms are very unsatisfactory and even if no charge was made for the folding crops the majority of the farms would have shown a loss on the sheep.

J.P.H.

Sugar Beet: Cost and Returns for the year 1928-29

A. Bridges and J. R. Lee, Oxford Agricultural Economics Research Institute.

This pamphlet presents the summarised results of the fifth year of the Institute's enquiry into the cost and returns from sugar beet growing in England and Wales. The number of cost statements received for the present crop (1928) was 437 relating to 1,518 acres of sugar beet and returns were obtained from thirteen districts in England and Wales. As in previous years a classification of the costs by soil groups and by geographical areas has been made. The labour costs per acre vary from £9 14s. 8d. for a yield of 8.51 tons on the light soil group to £13 13s. 8d. for a yield of 9.27 tons on the heavy soils group. As regards the various districts, the labour costs varied from £8 3s. 5d. per acre for a yield of 7.34 tons in the Yorkshire group to £13 per acre for a yield of 12.14 tons in the Devon and Cornwall group. A comparison is also made of the labour cost by soil groups for the crop years 1924-28 and by district groups for 1926-28.

The returns from 415 farms show an average direct cash profit of £2 17s. 4d. per acre and £4 19s. 3d. per acre when the values of residues are included. On a tonnage basis the cash profit was 6s. 5d. per ton and 11s. 1d. per ton (including residues). On the whole the financial results on the costed farms were good. Compared with the year 1927 costs were lower and the yields and sugar content and profits were higher. But the area of beet and the number of growers declined in 1928 as compared with 1927.

J.P.H.

Sugar Beet Costs in Devon and Cornwall, 1929

Department of Economics, Seale-Hayne Agricultural College, Newton Abbot, Devon. March, 1930.

This fourth report covers the cost of growing sugar beet over 418½ acres, or one third of the total crop of Devon and Cornwall. The average acreage each farm costed was under 4 acres. Average (washed) yield of beet per acre was 12.16 tons with an average sugar content (for 96 farms) of 17.8 per cent.

The high yields and sugar content account for the profits, for farm costs, as stated, were high.

The "profits" shown do not necessarily indicate total income receivable, for the "costs" include a charge of 15s. per acre to cover

cost of management and overheads. How much of this is expenditure and how much is equivalent to income is not shown. There are also other extensive assumptions which enter into the statements of costs of

Per acre.	*West Cornwall.*	*Mid-Cornwall.*	*North Devon.*	*East and Mid-Devon.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Total cost ...	24 11 9	26 14 4	23 17 3	25 8 10
Cash profit ...	10 12 6	5 16 6	7 12 4	3 4 11
Estimated profit (including Residues) ...	14 7 11	11 2 0	12 15 10	10 13 2

growing the crop. Any further analysis of these stated costs which tended to reduce the estimates could only have the effect of increasing estimated profits. It is probable that actual profits are greater than those shown. C.A.S.

Sugar Beet in the Eastern Counties, 1929

C. Burgess and P. E. Graves. Report No. 16. Cambridge School of Agriculture.

This report presents the results of an enquiry into the financial and economic aspects of sugar beet growing in the eastern counties. Two interim reports dealing respectively with the 1927 and 1928 sugar beet crop have already been published and this issue is intended to complete the series. The form in which the returns are presented corresponds with that used in previous issues. This procedure facilitates the comparison of the results year by year and renders the returns more valuable. The authors state that the objects of this report are (1) To demonstrate the results of sugar beet growing in the eastern counties in 1929 and to compare them with those of the two previous seasons; (2) On the evidence of the three years results, to draw attention to cause and effect relationships in the production of the crop; (3) To provide a basis for determining fair contract prices.

A summary of the average costs and returns for the three years shows that the net cost of growing sugar beet in 1927, 1928 and 1929 was £17 2s. 8d., £17 4s. 11d., and £16 8s. 8d. per acre respectively. For the same years the net profit per acre was £4 4s. 1d., £6 19s. 9d., and £8 12s. 9d. The average yield of beet has increased each year from 7.7 tons in 1927 to 9.3 tons in 1929. The average sugar content was 16.1 in 1927 and 17.9 per cent. in 1928 and 1929. J.P.H.

Sugar Beet (1929) in the Northern Counties

D. H. Dinsdale, Armstrong College, Newcastle-on-Tyne.

A report dealing with the results of an investigation in connection with the sugar beet crop in the counties of Northumberland, Durham, Cumberland and Westmorland. The results from 110 farms show that the financial returns (gross) vary from under £10 to over £30 per acre. Of these, sixty-two gave gross returns of under £18 and forty-six gave gross returns of over £18 per acre. The yields of washed beet varied from under 5 tons to over 15 tons per acre, and the range of sugar content was from 14.0 to 19.1 per cent. J.P.H.

AGRICULTURAL ECONOMICS; GENERAL

Agricultural Economics; A programme of Research in

J. S. King. *J. Proc. Agric. Econ. Society*, Vol. 1, No. 3.

A very useful survey of the scope and purposes of investigation in agricultural economics. The concern of agricultural economists is with the effects of those conditions, both internal and external to the industry, which influence the state of material well-being of those who derive all or part of their income from the exploitation of the productive forces in land utilised for farming. Their objects are to establish, and as far as possible to measure, the connections between cause and effect in the various relationships involved, in order that, by spreading knowledge of these connections, any adjustments that may be called for may be facilitated in the interests of the national well-being, or of agriculturists, or of both if these two should harmonize. Physical relationships are no concern of economic science, but the economist must be aware of them lest differences in returns to the application of resources, which would be more correctly ascribed to physical factors, be erroneously attributed to greater or less efficiency in organisation. There is a brief indication of the present position of research in Great Britain and suggestions as to the most desirable developments. Some limits of the scope of useful research are also suggested. Differences in organisation, etc., due to variations in environment and to variations in social structure and their economic results need investigation. Information is required on the supply of (economic) resources for use in agriculture and on the demand for agricultural services, and on the possibilities of amelioration of conditions arising from uncertain prices. The possibilities of co-ordinated action by groups of farmers (mainly in respect of marketing and ex-farm processes) should be studied. Finally, organisation of enquiries is briefly touched upon. Research in methodology which is needed should be kept on practical lines. A.W.A.

Agricultural Economics: International Conference

Report of First International Conference of Agricultural Economists, Dartington Hall, Devon, 1929. Mimeographed, bound, pages unnumbered. Pub. for private circulation, 1930.

This report contains about twenty-five papers, with abbreviated reports of discussions. The subjects include land tenure in various parts of the United Kingdom, accounting and farm management research in Great Britain, U.S.A., and Canada, milk marketing in England, marketing dairy produce and fruit and vegetables in U.S.A., co-operative marketing in Denmark, Norway and Finland, the farming situation in Germany, the economic situation in European agriculture, occupational distribution of wealth with special reference to incomes of American farmers, the tariff and farm relief in U.S.A., and some more general with some more technical subjects. In the copy used for this abstract the Table of Contents does not include all the chief papers and that by Dr. O. E. Baker on trends of agricultural production and population in U.S.A. is a notable omission. This is a useful collection of documents, and the contributions relating to Europe, especially Scandinavia, are particularly interesting. Discussions of the broader

aspects of the economic situation in American agriculture are stimulating and useful. The reports of open discussions do not always provide an adequate indication of actual statements. A.W.A.

Farm Management: Application of data to farm practice in the United States

R. Mc. G. Carslaw. *J. Proc. Agric. Econ. Society*, Vol. 1, No. 3.

Farm management studies are primarily concerned with the individualistic aspects of the economic results of farming. Different conditions have called forth different methods of investigation. Methods have been experimental, and modifications are introduced as a result of experience. The origin of studies in U.S.A., early use of costings, and the development of surveys are briefly discussed. Financial accounts are the latest development in method, but are providing such valuable results that it appears likely they will soon occupy premier place in the extension programmes of most of the colleges. Cost investigations have lost their prestige. There are comprehensive quotations from the reports of farm management investigations and an illustration of an "efficiency chart" is provided. Some schemes of investigation are partly supported by farmers. The teaching of financial accounts in many States now starts in rural schools. Lectures, tours of inspection to profitable farms, exhibits, contests, prompted newspaper articles, etc., all assist in the dissemination of farm management knowledge. The "Outlook" reports of the Bureau of Agricultural Economics give timely information on the long and short-time changes in production, prices, consumption, movements of farm products *inter alia*, and provide a source of intelligence for advisory workers. American agricultural economists have "delivered the goods" to the practical farmer with considerable success. A.W.A.

Economeg Amaethyddiaeth.

gan J. Morgan Jones, M.A. td. 151. Pris. 2s. 6ch.

This book is one of a series of volumes published by the Press Board of the University of Wales, the general object aimed at being the provision in the Welsh language of something comparable to what is well-known to English readers in The Home University Library. The volume under notice deals with the subject of Agricultural Economics and has been written by Mr. J. Morgan Jones, now of the Markets Branch of the Ministry of Agriculture, but who until recently was on the Staff of the Agricultural Economics Department of the University College, Aberystwyth. The author is one of a band of young agricultural economists associated with that Department and has done distinguished work by his investigation of a number of agricultural problems in Wales. He is thus eminently qualified to undertake the preparation of a book of this kind, which is intended to give in a small compass an accurate idea of what the science of Agricultural Economics means and its bearing upon the everyday business of the farmer. The book covers, briefly but adequately for its purpose, a wide field and deals with land, labour, capital organisation, prices, and marketing. It contains a useful bibliography and a very full index.

The preparation of a book on such a subject as this in Welsh, and to render the text in such a form as will not strike the ordinary Welsh reader at once as unfamiliar, is not an easy matter, but Mr. Morgan

Jones has, in this as in other respects, performed a difficult task exceedingly well. Both in style and matter the book answers admirably the purpose it is intended to serve and gives to the Welsh reader a treatise on an important subject that is quite equal in merit to anything of the same scope and character that is available in English.

C.B.J.

FARM LABOUR.

Farm Labour Requirements; The Seasonal Distribution of

W. H. KIRKPATRICK, Cambridge School of Agriculture.

This publication dealing with the labour requirements is based on data obtained from the labour records (manual, horse and tractor) of twelve fully costed farms, distributed throughout the counties of Cambridge, Essex, Huntingdon, Norfolk and Suffolk for the two years 1927 and 1928 and thus represent twenty-four farming years.

The distribution of the horse and manual labour is analysed very carefully and the results are fully discussed. The report contains a number of charts and tables showing the seasonal variation in the total hours worked, the seasonal distribution of labour required for different crops, cows, work horses and for establishment work, etc.

The writer emphasises the fact that labour costs form a large proportion of the total costs of the farm, and that labour at the present day is about twice as expensive as in pre-war days, while the farmer's produce is fetching less than one and a half times as much. The alternative to a reduction in wages is a more efficient organisation of labour and consequently a greater output per unit. It is with the object of assisting in such organisation that this study has been made. The author states that the conclusions are merely of a tentative nature and must be regarded as a prelude to a fuller consideration of the use and organisation of agricultural labour in the eastern counties.

J.P.H.

Farm Labour in Germany: The study of

J. MORGAN JONES. *J. of Proc. Agric. Econ Society*, Vol. 1, No. 3, 1930. No. 3, 1930.

This paper contains some of the summary results of a personal examination of the methods of scientific investigation of the foundations and conditions of economy in the use of farm labour as conducted in Germany. There has been migration of labour from German agriculture, and some shortage in supply. The demand for labour in some types of farming and particularly for some crops is seasonal in character. There is necessity for raising wages to ensure a supply of labour, but the general financial results of farming have been too poor to provide for increase in wages without increase in efficiency of labour and in output per unit. Hence the study of *Landarbeitslehre*. Some studies like those of fatigue are partly of a physiological character, and partly of the arrangement of tasks. Others are concerned with tools and their suitability for the work required, while others are concerned with machinery and its use. Still other studies are related to the organisation for the accomplishment of tasks by groups of workers and accompanying equipment. But studies extend into the region of the dovetailing of farm enterprises (crops or crops and stock) as regards labour requirements. Finally, the whole organisation of the human

factors on the farm and the use of capital equipment, with " management " as well as " labour " concerned, are brought under examination; and the studies extend somewhat into the human if not the moral basis of efficiency and to remuneration as affecting output of work. The discussion of methods over such a field is necessarily brief. The conclusion states that students of *Landarbeitslehre* have reason to be proud of the contribution which their young science has made to the solution of Germany's post-war agricultural problems. A.W.A.

Farm Labour Processes in Germany: Improvement in the technique of J. MORGAN JONES. Mimeographed for private circulation, foolscap, 29 pp., 1930. Development Commission and Ministry of Agriculture.

A more elaborate statement of the results of the personal examination of the scope, objects, and methods of *Landarbeitslehre* mentioned above. Engineering, farm organisation, physiology, psychology are all represented in the basic studies, and in organisation of research work by persons who are more or less specialists. And at times studies extend almost into the region of rural sociology. The different types of labour problems arising on large and small farms respectively are noted, but the basic problem is the unequal seasonal demand which the farming systems make on labour of all kinds. This problem has been accentuated by the great decrease in the supply of seasonal immigrants as well as by migration of native farm workers. The chief reasons for rural migration are disparity between industrial and agricultural wages, and comparative lack of attraction of agricultural work and rural life. The objects of study of labour processes are those of securing economy in work and rendering it easier by the most suitable organisation and the provision of the most suitable accessories; and of raising work output through improved methods of work and payment; but other and more extensive indications of scope and work are given. One broad method of study follows use of labour in general farm organisation, recording amounts used and conditions of use, for the purpose of obtaining information on seasonal and total requirements under different conditions, for the fixing of standard requirements and for the compilation of a " labour intensity index " which may be applied as a criterion of labour management on different farms. But as the results of this method raised more problems than they solved, systems of examining conditions and results of labour in detail became necessary. Types of specialised study are concerned with time and output in work; tools, implements and machines; methods and motions and conditions of fatigue in manual operations; organisation of group tasks; influence of systems and amounts of remuneration; and general human relationships on the farms. There is a brief description of the organisation of research, which is of extensive character providing for specialisation at certain centres. Some farmers organise Rings for labour research on their farms, and provide financial support. Research has led to extension work, in which farm workers' unions and farmers co-operate. A beginning has been made in the vocational selection of farm workers. The conclusion as regards the practical results of studies is that they are rendering a real service to German agriculture, suspicions and prejudices of both employers and employees are being broken down and there is considerable movement towards the practical application of results of

investigation. Appendices include a short bibliography, a list of current research projects at Bornim, a statement of programme of D.L.G. Labour Research Rings, and a syllabus of courses in *Landarbeitslehre.*

A.W.A.

EMPIRE MARKETING BOARD: REPORTS AND STUDIES.

Annual Report of the Empire Marketing Board, 1929-30

E.M.B. Series, No. 28, June, 1930.

A report of the activities and progress of a non-political body established by Parliament in 1926 for the purpose of furthering the marketing in the United Kingdom of Empire products including those of this country. The activities of the Board are maintained by an annual grant from Parliament and from various grants made by private and public bodies for specific pieces of research. The sum proposed for Parliamentary sanction for the year 1930-31 is £800,000.

There has been a steady extension of the marketing studies, propaganda and assistance provided by the Board. The " National Mark " as a factor of prime importance in placing home grown foodstuffs on an orderly marketing basis has been actively assisted by the Board, to the extent of some £52,000 a year for England and Wales, as well as by advertisements and other forms of publicity.

Scientific research conducted with the aid of grants from the E.M.B. is now in progress in the United Kingdom, in each of the Dominions and in numerous Colonies. The report gives particulars of each grant and of progress made in all investigations financed by the Board. Excluding the many investigations conducted at universities, colleges and research stations there would appear to be some seventy highly specialised and widely diverse research projects sponsored by the Board in almost every part of the Empire. But it is significant that all expenditure is for the direct benefit of the White producer. There are many economic investigations most urgently needed, both on the production and marketing sides, to assist the coloured members of the Empire, who outnumber the white by about five to one, to better their very primitive conditions of farming. The improvement of this class of cultivation is of vital importance to the improvement of the trade of this country.

C.A.S.

British Industries and Empire Markets

E.M.B. Series, No. 26, March, 1930.

A searching review by Professor A. J. Sargent, M.A., of the export trade of this country, illustrated by a series of analytical tables and diagrams interspaced with deeply reasoned explanations to emphasise the opinion that the British Empire presents a more favourable market for home exports than does Europe and other non-Empire parts of the world. The author states that Great Britain is merely a gigantic urban area dependent for its very existence on the supply of food and raw materials from without and these are largely purchased by the products of its manufacturing industries. The basis of the author's contention for concentrating upon increased trade with the rest of the Empire appears to be numerical strength as represented by total population. An analysis, however, of the Empire population is disturbing. The Empire consists of some 450 millions of people, 15 per cent of whom are whites of various nationalities, the remaining 85 per cent. consisting principally of Indians (72 per cent.) and Africans (11 per cent.).

It is beyond dispute that the bulk of these Indians and Africans possess little or no "wealth" although they produce it for others. They are the lowest paid producers, or workers, in the world. Until definite provision is made to educate and organise them to acquire some higher standard of living, trade within the Empire will show little improvement. Further, as to the 35 millions of whites who people the Dominions and Colonies, the great majority, excluding the administration services and those in Africa and elsewhere who are able to command cheap, docile native labour, are engaged in agricultural pursuits, and are dependent upon the results of agriculture, an occupation to-day which offers little more than a bare living.

Professor Sargent's statement: "There is a limit to the quantity of any particular kind of goods which an individual, or groups of individuals, can consume apart altogether from the question of price" can be applied with the greatest emphasis to the Indian, African and that part of the white population engaged in cultivating the soil and particularly with regard to the price factor. C.A.S.

Canadian Fruit Shipments

E.M.B. Series, No. 30, June, 1930.

A systematic survey has been carried out as to the nature and extent of deterioration in imported fruit with the object of indentifying the most serious types of wastage and assessing their relative importance. Accounts are given of the importation of Canadian apples into the United Kingdom including particulars of the quantities and varieties shipped, the method of packing and the carrying temperatures. The principal types of wastage observed are described and discussed in relation to such factors as variety, grade, size and maturity. Pears, plums and peaches are treated in a similar manner. This type of investigation will become increasingly important as the methods of storage and of preservation of foodstuffs are more commonly used in agricultural commerce. C.A.S

Cocoa; World Production and Trade

E.M.B. Series, No. 27, May, 1930.

This is a statistical record of the world trade in cacao and its products. By means of the 103 tables and diagrams this trade is traced country by country during recent years. The consumption of cocoa in the United States of America and in European countries has rapidly risen, but the rate of increase has suffered a check. Contributory causes are stated to be the slowing up of demand for chocolate due to the increased use of tobacco among women, dieting and the increased consumption of fruit. The reader will search in vain among the 100 tables for a summary of world production by countries of origin. But it would appear that production during the period 1924-28 averaged 494,000 tons, of which 62 per cent. was of Empire origin. Of Empire supplies 45 per cent. was produced in the Gold Coast Colony. The chief cocoa producing countries are the Gold Coast Colony, Brazil, Nigeria, Ecuador and Trinidad. Cacao cultivation has been badly neglected in the Gold Coast Colony with the consequent lowering of quality and depletion of the main source of the Colony's revenue. When a colony is dependent upon a single crop for its principal source of revenue, as in this instance,

or as Uganda is dependent upon its cotton crop, it is a mistaken policy to encourage unlimited cultivation without exercising measures to enforce the elementary rules of field husbandry in the initial development stage. C.A.S.

Cod Liver Oil from various sources; The Relative Values of

E.M.B. Series, No. 35, December, 1930.

The report of a comprehensive study of the composition of cod liver oil, its manufacture and its medicinal value carried out by Professors J. C. Drummond and T. P. Hilditch on behalf of the Empire Marketing Board. The investigators state that many inferior grades of cod liver oil and adulterated oils are sold for farm use. " This is highly undesirable and should not be tolerated ". Oil intended for cattle and poultry should be of a quality little inferior to that employed for human consumption.

A re-investigation has been made by the problem of the origin of the important dietary factors, Vitamin A and Vitamin D, in cod liver oil as a necessary step in ascertaining the cause of the variations in medicinal value which occur in oils from different localities. Evidence was established that the higher the yield of oil from the livers the lower, relatively speaking, will be its vitamins content. Of the oils from the important cod areas studied, those from Newfoundland were found to be of richest vitamin potency. Throughout manufacture and processing air contact with the oil should be reduced to a minimum as the vitamin content is lowered by oxidation and other undesirable changes are brought about. When glass containers are used they should be of a dark amber colour and not of the ordinary white glass variety.

C.A.S.

Rice in British Guiana; Report on the Cultivation, Treatment and Prospects of

E.M.B. Series, No. 32, August, 1930.

A comprehensive investigation into the present condition of rice growing and of the future prospects of the crop in the Colony of British Guiana. It is drawn up in a very readable manner with interesting maps, diagrams and photographs. A reader without any knowledge of rice technique can quite easily follow the author and appreciate his recommendations, some of which are equally applicable to tropical crops other than rice. It is a pity that the tables of production costs are given in terms of dollars of an unknown denomination. C.A.S.

Indian (Sunn or Sann) Hemp; Its Production and Utilisation

E.M.B. Series, 25, February, 1930.

A memorandum prepared by the Imperial Institute upon a plant which plays an important part in the economics of Indian agriculture. The extension of its cultivation is important, as it supplies both a cheap but valuable organic manure and a marketable fibre. Hitherto its cultivation as a commercial crop and the subsequent marketing arrangements have been unsatisfactory. It has been proved that entirely satisfactory " Indian hemp " (Sunn hemp) can be produced in India and also in tropical Africa The crop is particularly suitable for growing in rotation with cotton, sugarcane, maize, etc. It has the merits of freedom from disease and requires no weeding or irrigation. If one half

of its reputed qualities mature this plant should be of the greatest value in the extension of the rather narrow rotation generally practised in tropical agriculture. C.A.S.

The Dissemination of Research Results among Agricultural Producers
E.M.B. Series, No. 33, September, 1930.

As most of the Empire Marketing Board's grants for research are designed to benefit the primary producer it was considered to be a matter of interest to the Board to know how the results of the scientific investigations conducted in the various countries were applied in practice. A questionnaire was circulated to all Empire Governments in 1927 seeking information as to methods adopted to convey the results of agricultural research to the land worker. The replies to this questionnaire form the body of this report which consists of 135 pages of exceedingly interesting matter to those who wish to become better acquainted with methods employed for furthering agricultural education within the Empire. Not the least interesting part is the Introduction written by Sir Daniel Hall, which can be read with profit by all who are interested in the cultivation of the soil in this country or overseas. C.A.S.

The Growing Dependence of British Industry upon Empire Markets
E. L. McDougall, C.M.G., E.M.B. Series, 23, December, 1929.

This paper represents the personal opinion of the author, for which the Empire Marketing Board accept no responsibility. It is a controversial treatise upon the expansion of Empire trade with this country and, like so many others of its kind, fails to appreciate the rather definite limitations of such expansion. Nevertheless a study of the many carefully compiled tables it contains is well worth the time involved.

Trade in manufactured goods has become intensified in every market of the world and the object of this work is to point out that the position of British trade is far more favourable in Empire markets than in foreign markets. It is stated that in Empire markets, taken as a whole, Great Britain supplies about 36 per cent. of the imports but that since the war Great Britain's share has tended to decrease. With the exception of those parts of the Empire which fall directly within the economic sphere of the United States of America, Great Britain retains a position of definite predominance. But the United States of America is making considerable inroads into the Empire markets. The percentage of British and the U.S.A. share in Canadian imports for the years 1913, 1927 and 1928 was—British, 21.3; 16.8; 15.6. U.S.A., 64.0; 64.9; 67.6. In the markets of Australia and New Zealand the United States of America has gained to the extent that Great Britain has lost. But as regards export value Great Britain, making allowance for price change, has exceeded the 1913 level by £2 or £3 millions.

The percentage share taken by Great Britain in the import trade of India fell from 64 per cent. in 1913 to 47 per cent. in 1927. British exports, measured in 1913 price levels, also fell from £70 million to £52 millions. Both the U.S.A. and Japan have considerably expanded their export trade with India. Greatest development of our overseas trade would appear to lie with the Colonies and Protectorates During the period 1924-1927 the import trade of the Colonies, taken as a whole, increased from £187 millions to £247 millions and British exports to the Colonies rose from £47 millions to £55 millions in the same period.

The writer concludes that by taking advantage of the increasing purchasing power of British goods operating in the sheltered markets of the Empire, Great Britain should be able effectively to increase the output of her export trades. C.A.S.

Tung Oil in the Empire; The Production of

E.M.B. Series, No. 31, June, 1930.

A memorandum prepared by the Imperial Institute summarising available information upon the cultivation of Tung trees (*Aleurites Fordii*) in order to judge the feasibility of supplying British needs for this oil by the cultivation of the trees within the Empire.

This oil, commonly called Chinese Wood Oil, is an essential raw material of the varnish manufacturer and is indispensable where a tough water-resistant film of high gloss is desired. It constitutes one of the chief exports of China, worth approximately three million pounds sterling annually. There is keen competition for the oil and a high price level is maintained. Plantations have already been started in the United States of America and are rapidly developing. Supplies of seeds obtained from China and Florida have now been distributed for experimental purposes in many parts of the Empire and preliminary reports from some countries, especially from North East India, are encouraging. C.A.S.

OWNERSHIP OF LAND.

Landowning; The Economics of Rural

W. C. D. Dampier Whetham. *J. Proc. Agric. Econ. Society*, Vol. 1, No. 3.

The essence of this paper is the statistical study of gross rents, outgoings and net rents on two groups of estates, one under private ownership and one owned by colleges, during the period 1913 to 1929. Over 276,136 acres the total gross income was £231,282. Statutory and fixed (public) charges represent 10 per cent. of gross income; maintenance, insurance, and management 43.2 per cent., and net income 16.8 per cent. But taking each estate as a unit irrespective of acreage the average net represented only 41.7 per cent. of average gross income. Net returns as percentages of gross rentals are set out for seventeen estates and a frequency distribution chart is given. Results of previous similar investigations are quoted and comparisons are made. The real income of rural landowners has been diminished by half since 1914, and the present trend of rents is downwards. Rents follow farming profits closely downwards though slowly upwards. Recent legislation has made rural landowning unsatisfactory. Direct taxation does not enter into primary costs of production but it does reduce the resources available for maintenance and improvements. A scientific study with candid but fine-tempered comments by one who is financially interested in rural land. A.W.A.

FOOD SUPPLIES AND CONSUMPTION

Agricultural Production and Population; Trends of—with special reference to the United States of America

O. E. Baker. U.S. Department of Agriculture. Report of First International Conference of Agricultural Economists, Dartington Hall, Devon, 1929.

We approach an era in which the arts of exploiting the world's natural resources will continue to advance while population in the

Occident becomes stationary. The increase in population during the last two centuries has been unique in the world's history, but Malthus' prediction of pressure of population on food supply has been proved to be unfounded. There has been expansion of pastoral and arable land in use, yields have increased, machinery has multiplied man's power of production. Production in U.S.A. has increased more rapidly than acreages under crops or numbers of animals. Mechanization has released land used for production of feed for draft animals, and carried grain production into semi-arid regions. There has been a change from the less to the more productive crops, and from the less to the more productive animals. A great improvement in the amount of milk and meat produced per unit of feed consumed has occurred. On the consumption side, there has been reduction in the quantities of cereals consumed, and an increase in consumption of foodstuffs from animal sources. There has been a recent increase in consumption of pig-meat, but as compared with thirty years ago there is smaller consumption of beef and veal and of mutton and lamb. Consumption of milk and dairy produce shows a large increase. During the last ten years population of U.S.A. has increased about 1.1 per cent. a year but the increase is diminishing; agricultural production during the last decade has increased, on the average, about 2 per cent. a year. The future trend of population is discussed at some length, and conditions of agricultural production and population in some other countries are briefly noticed. The diagrams are particularly clear and useful. No short abstract could do justice to this paper, which deals broadly with the fundamental economics of production and consumption of foodstuffs. The pity is that it has no counterpart in studies of British agriculture.

A.W.A.

MARKETING AND PRICES.

Agricultural Co-operation in Scotland; Report of the Committee on *Cmd.*, 3567. H.M.S.O., 1930.

Part I of this report is devoted to a review of the present position of the agricultural co-operative movement in Scotland. The importance of the movement is shown by the statement of total trade turnover in 1928 of over £2¼ million, whilst the variety of businesses undertaken and their distribution is shown in Appendix I.

The more important topic of future development is dealt with in Part II, which contains many interesting recommendations. A proposal for the organisation of the movement in Scotland is shown diagrammatically in Appendix II. Two distinct groups (*a*) supply societies and (*b*) marketing agencies should be affiliated to the Scottish Agricultural Organisation Society for propaganda and educational purposes. To secure greater co-ordination amongst the societies for the administration of finance, etc., a Scottish Agricultural Co-operative Federation should be formed, through which an Agricultural Finance Committee should administer state credit. As a result of the experience of the Scottish Milk Agency considerable attention is devoted to the problem of produce surpluses. The fear that a minority of outside producers will wreck any scheme deters members from joining and has had a retarding effect upon the formation of marketing agencies. The committee would see no danger to producers, consumers, or the community

generally if a marketing agency had the right to compel a minority of producers to market a commodity through the agency provided it represented 75 per cent. of the producers of that commodity. All interests could be safeguarded and it is suggested that consumers could have representation on the governing body to prevent fixation of monopoly price or restriction of production sufficient to force scarcity prices.

In the vexed question of imports the committee state definitely the first necessity is to bring order into the marketing of home produce. It is admitted, however, that disguised subsidies and the operation of speculators in foreign produce will negative any attempt at stabilising the prices of home produce, and it is submitted that it is necessary for the health of the agricultural industry to prevent fluctuation in prices by uncontrolled imports. J.G.W.

Butter; The Demand for Empire

Empire Marketing Board, Series No. 31, 1930.

The result of an enquiry into the position of Empire butter in the retail shops of the main centres of population in the United Kingdom and an estimation of the extent and nature of the competition from butters of foreign origin.

In 1929, nearly 6½ millions hundredweights of butter were imported into the United Kingdom, and probably less than one million hundredweight was produced at home. The chief sources of supply of total imports were: Denmark 34 per cent., other foreign countries 24 per cent., New Zealand 24 per cent., Australia 12 per cent. and the Irish Free State 9 per cent. In all, the imports from the Overseas Empire, together with the production in the United Kingdom, were approximately equal to the imports from foreign countries. The main markets for each type of imported butter tend to be grouped round the ports of entry.

New Zealand butter was most frequently stocked in the South, and, in the earlier months of the year, in Liverpool. In Yorkshire and Scotland it was moderately frequent in Non-Local Multiples, but rare in other shops. Australian butter was most popular in London and Birmingham. Like New Zealand butter, it was rarely stocked in the North and East.

Irish butter, which was not available in quantity until June, found its main market in the West and in South Wales. In Liverpool it was comparable with Danish; in Glasgow it was second to Danish. Many of the stockists of Irish butter change over to New Zealand or Australian in the winter months.

Danish butter was the staple type in the North and East. In Liverpool and Birmingham it was about equal to Empire butter in popularity; in London, Bristol and South Wales it was much less commonly found.

Home farm butter was mostly retailed in the country districts, and was seldom brought into the population centres in which the enquiry was conducted.

The information summarised in the report was obtained by personal enquiry during two periods, April to June and from July to September,

1929, from 2,918 representative shops. The enquiry was conducted in eighteen towns, the total population covered being around 12 millions.

C.A.S.

Co-operative Trading in Agricultural Requisites; Influence of Finance on the results of

J. MORGAN JONES. *The Co-operative Review*, January and March, 1930.

A study based upon the analysis of sixty agricultural co-operative societies in Wales. The group is divided into three sub-groups on the basis of " financial balances ", *i.e.*, the difference between the earnings and the costs of capital used in the businesses. Earnings of capital include bank and investment interest and discounts for prompt payment of cash, whilst costs of capital are loan, bank, and mortgage charges, interest payments on overdue accounts and discount allowances to purchasers who pay promptly. The study shows an intimate relationship between financial and trading conditions, the results of trading tending to be less favourable when financial conditions are not satisfactory.

The uses of total capital and of trading capital are discussed, together with credit considerations. By a study of successful societies, a theoretical standard for the use of trade capital has been estimated, and this is used as a basis for comparison with the actual use made by the three sub-groups. The final conclusion is that the prospects of profit making are normally greater in the adequately financed society than in one which has to rely on borrowed capital. J.G.W.

Dairy Produce in England and Wales; Report on the Marketing of. Part I. Cheese

Economic Series, No. 22. Ministry of Agriculture. H.M.S.O., 1930.

As a contribution to the problem of disposal of surplus milk, this publication should interest all connected in any way with the liquid milk trade. It is a comprehensive survey of the cheese making industry dealing with production, supplies and demand, preparation for marketing and distribution, transportation and the problems of storage. The technical problems of manufacture are introduced only so far as they affect problems of marketing and distribution.

The possibility of further extension of the cheese making industry in this country is limited because of variability in the product. The quality of the best home produced farm-made cheese is higher than that of the best imported produce, but unfortunately the proportion of farm output which commands top prices is not large and its merits are largely offset by the variable quality of the remainder. The desirability of securing greater uniformity is emphasised and accordingly a suggested scheme for grading the home produced product and marking it with the National Mark is outlined.

At present, the factory manufacture of cheese tends to be regarded merely an ancillary to the distribution of fluid milk, but the reports anticipate further expansion of factories with increased milk production. With this in view attention is devoted to the better utilisation of the bye-products.

No radical changes in marketing methods are recommended, but the provision of better storage accommodation is suggested as a remedy for the wide variations in the price of Cheshire cheese. J.G.W.

Farmers' Co-operative Associations in the United States, 1929

U.S.D.A. Circular, No. 94, 1930. Washington, D.C.

A descriptive and statistical study of the agricultural co-operative movement in the United States of America in 1929. J.G.W.

Fluid Milk; Co-operative Marketing of

HUTZEL METZGER. *Technical Bulletin*, No. 179. U.S.D.A. Washington D.C.

The principal findings from a study of the developments and methods of operation of 159 Co-operative Milk Marketing Associations which marketed approximately two-fifths of the milk sold in United States of America in 1928 are presented in this bulletin. The first association was formed in 1882; by 1914 there were fourteen in operation, and in the following ten years the number rose to 117. A brief history of the development is given with short interesting references to several milk "strikes" which have occurred, whilst the latter portion of the bulletin is devoted to a detailed description of eight representative associations.

The associations are divided into two distinct types (1) bargaining associations and (2) marketing or operating associations, although many modifications and combinations of these are found in the associations discussed in the text. The activities of bargaining associations are mainly confined to the functions of brokers in arranging for the sale of members' supplies. They do not operate any facilities for the physical handling of milk. Operating or marketing associations actually handle milk, in addition to acting as bargaining associations. The functions, advantages and disadvantages of both types are discussed in detail.

Two sections of particular interest are those on price policies and plans, and control of production and seasonal variations. The flat price plan, the accepted method a decade ago, has now given way to the "classification" or "use" plan. The theoretical problem of fixing surplus milk price is outlined, together with detailed statements of the price fixing methods of selected co-operative associations.

Two plans for the control of production and seasonal variation are discussed and actual results achieved by both methods are shown. Under the "basic surplus" plan, the individual producer is assigned a definite quantity and any supplies above this are paid at the surplus rate. Under the contract plan the producer himself names the basic quantity on which payment for his supplies will be fixed with a penalty for variation either above or below. In a discussion of the results of these plans, the author states that both have proved effective in adjusting production "and it is probable that the principles of either plan may be applied successfully in any area".

The study is a very useful contribution to the subject, especially in view of possible marketing developments in the liquid milk trade in this country. J.G.W.

Fruit and Vegetables in the Vale of Evesham; Marketing of

M. A. ABRAMS. *Aconcroft Rural Studies*, I. Offenham, Evesham, 1930.

The products mainly dealt with are cabbages, asparagus and plums, which differ considerably in the nature of their markets, but conditions in the markets for other products are discussed. The general consideration covers conditions of production, present financial position of

growers, suggested causes of depression, natural difficulties of marketing, the distributive process—with description of some local institutions, transport, retailers' operations and trading conditions; packing and grading. The position appears to be that in the midst of a severe trade depression the ordinary fruit and vegetable retailer is making a " fair " profit on his capital and earning a " fair " wage, and that in order to attain this enviable position he finds it necessary and possible to work on a gross profit of about 45 per cent. on his buying prices. On the other hand the legitimate expectations of all growers have been disappointed in recent years, but the burden of adversity, both absolutely and relatively, has fallen on the small grower. The vast majority of small holders (five to fifteen acres) have fallen behind financially in the last two years. (Thus the growers, especially on the smaller scale, have failed to obtain " fair " wages and " fair " return on capital, using the term " fair " in the same sense as applied to retailers' profits. There seems no reason to believe that the producer, as things are at present organised, could attach to himself a larger proportion of the retailers' gross profit margin. Therefore, the producer must change his ways, but the retailer need not and, apparently, society cannot expect him to do so). The weakness of this study is in the tendency to apply different criteria to the operations of primary producers and to those of the commercial classes. However, there is need of producers' activity in creating conditions leading to less wastage and better presentation of goods. The bargaining strength of the growers can be increased through co operative selling; and better selection, grading, and packing of produce with the reduced costs of handling. The many details are of great interest and the whole study is attractively presented. A.W.A.

Hides and Skins; Sixteenth Report of the Imperial Economic Committee. H.M.S.O., 1930.

This report contains very useful information regarding countries of origin, trade, preparation and marketing of this material. Before the finished leather article is sold to the public, three important industries have been involved—the trade in the raw products, the tanning industry, and the leather manufacturing industry. Primary producers other than pastoralists who have little of possibilities of marketing meat pay relatively little attention to these products and the conditions of the trade.

Net imports into the United Kingdom in 1928 of hides and skins were valued at £15,500,000. The value of home supplies, less exports, in the same year, was estimated at £5,800,000.

The Empire, as a whole, produces a surplus of hides and skins, except the heavy hides, above the requirements of its leather industries. The report is emphatic as to the necessity for farmers to take much greater interest in the prevention of damage to the hide of the living animal. Annual damage to hides in the United Kingdom is very heavy. It is not generally realised by farmers that the tanner pays about £2 for a hide in good condition from an average bullock. The report does not give any figure for damage caused to cattle and hides in this country by the Warble Fly, but it is estimated at £1,000,000 a year, whilst annual loss suffered by bad flaying and careless preservation of hides is at least £500,000. C.A.S.

Markets and Fairs in England and Wales.

Part V. Welsh Markets.

Part VI. London Markets.

Part VII. Final Review.

Economic Series, No. 26, Ministry of Agriculture. H.M.S.O., 1930.

The last three of the series of Reports on the Markets and Fairs of England and Wales are published in this single volume.

The first section of Part V summarises the Welsh markets and fairs as a whole, and discusses the general situation as regards markets for agricultural produce in Wales. This is followed by a detailed report on the methods of sale, together with criticisms and suggestions for improvement, of the various types of agricultural produce.

In Section II each county area (excluding Monmouthshire) is taken singly and the general agricultural conditions and production in relation to its markets are discussed. Notes are added regarding particular markets in each area, giving general information as to ownership, geographical position, trade, area of supplies and destination of produce sold. The scattered references throughout the report to the movement of livestock and produce in Wales should be of particular interest to students of Welsh agricultural conditions. The appendices include a complete list of the markets and fairs in Wales, with the name of the owner, market day and character of the market, *i.e.*, whether livestock, butter and eggs, pigs or general produce.

Part VI of the series referring to the London markets differs from the preceding reports in that it discusses questions of national importance relating to markets and a much wider variety of types, including, as it does, fish, sugar, hides and skins and hops. The descriptive section relating to some of the markets and exchanges giving information as to their history, situation and approaches, accommodation, charges, trade and selling methods are of interest, particularly the portions referring to Covent Garden and the Metropolitan Cattle Market, Islington, and the London Central Meat Markets.

Part VII reviews the introductory report (Part I of the series) in the light of the detailed investigations made throughout the country. The principle that there should be some form of public control over markets is advocated on the basis that they are essentially a public service. Even where markets are established under legal title it is shown that they may not be able to fulfil a useful function to-day due to technical legalities in their charter. The necessity for greater freedom under central public control, together with a limitation in the indiscriminate organisation of markets not being markets in law is emphasised. The suggestion that some form of regional body should be set up with a view to the elimination of the small uneconomically and financially unsound markets is repeated. J.G.W.

Potatoes in Great Britain; Factors affecting the Price of

RUTH L. COHEN, B.A. *Report* No. 15. *Farm Economics Branch, University of Cambridge.*

A statistical study of the price movements of potatoes. The difficulty in securing relevant and comparable data is fully appreciated, but nevertheless interesting results are made available.

Home production is the most important factor as regards prices, and the fluctuation in acreage, whilst not negligible is not so important as yield per acre. Imports of potatoes are shown to be dependent upon

price and not price upon the imports of potatoes. Although the increase in price is checked by foreign shipments it is maintained that were these importations to cease the consequent rise in price would be followed by an increase in acreage. Therefore, it is more justifiable to say that imports restrict acreage of potatoes than that they depress price. Thus the effect of foreign supplies is to stabilise the minor causal factor in price fluctuations.

The analysis thus indicates that little can be done to alter variations in supply so long as fluctuations in yield continue. For such movements are not sufficiently regular for it to be possible to advise farmers to alter their acreage in the opposite direction to variation in yield. Hence, apart from attempts to stabilise yields, no substantial steps can be taken to stabilise retail prices from season to season. J.G.W.

Poultry Industry; Economics of

Papers prepared for the Fourth World's Poultry Congress (Economics and Marketing Section). Ministry of Agriculture, 1930.

A volume containing twenty-nine papers relating to nine countries and one paper submitted by the International Institute of Agriculture, which were read at the meetings of the Economics (and Marketing) Section. The statistical studies include statements for the Netherlands, Belgium, Italy and Portugal. The paper provided by the International Institute gives data on the production and trade in poultry and eggs in various countries.

On the Co-operative Marketing side, two papers discuss the problem with specific reference to Canadian conditions, and one refers to the operation of an Egg, Feed and Poultry Co-operative operating in Central California. By far the most important topic was general marketing, which is discussed in eleven papers. Marketing methods and Government control in Northern Ireland, Scotland, the Irish Free State and South Africa are outlined and a statement is included on the marketing of poultry products under the National Mark Scheme in England and Wales. The three studies of the British market for imported eggs, imported table poultry, and some aspects of the London retail trade are particularly interesting. Two further papers discuss marketing from the American standpoint. Throughout these papers the advantages of grading are emphasised as a means of curtailing the distributive chain and levelling out egg prices.

The important topic of prices and price reporting is discussed in three papers, one being a study of prices in Great Britain. The remaining two papers are discussions submitted by American authorities on the difficult problems of price reporting. The remaining papers deal with a variety of topics such as cold storage, canning and results of survey records.

The whole series forms a valuable contribution to the general economic literature of the poultry industry, dealing as it does with such a variety of topics by eminent authorities. J.G.W.

Retail Feed Stores in New York State; Some factors affecting the Cost of

WHITON POWELL. Cornell University, Ithaca, New York.

A comprehensive and statistical study of the financial aspects of the trading of eighty-three retail feed stores in New York State carried out with a view to verifying the financial and operating standards obtained

in a previous study in 1924. An effort is also made to determine and measure statistically the influence of factors affecting the efficiency of retail feed store operation.

The study of capital investment shows an allocation of one-fourth in fixed property; more than one-third in credit; less than one-third in inventory (stocks in hand, etc.); about one-tenth in cash and the remainder in miscellaneous small items. It is stated that for sound financing more than 60 per cent. of the total liabilities should be contributed by the owners and that current assets should not be less than twice the current liabilities. A total capital turnover of 2.75 times per annum with an inventory turnover of ten times per year appears to be typical of the group. The number of days' sales outstanding (credit) being 46.8 or 1.8 months. A study of the factors affecting efficiency of operation is prefaced by an interesting discussion upon the concept of efficiency itself. Four operating ratios which are considered to affect total costs are calculated, sales per employee, number of days' sale outstanding in receivables, inventory turnover and fixed property turnover. Using multiple correlations, it was found that these four factors alone accounted for 69.0 per cent. of the total variation in costs. By using four additional factors, (1) per cent. sales for cash, (2) per cent. sales from car door, (3) per cent. of sales delivered, and (4) distance from railroad sidings, the total determination was only increased to 72 per cent. It was found, however, that the four operating ratios plus the factor of distance from railroad sidings accounted for 72 per cent. of the variation in costs of operation. The various operating ratios are inter-correlated so that each shows some of the effect of the others on costs.

The stores with the largest net profits in terms of dollars, tended to have larger net sales, and larger percentages of net profit. Large net profits result from both larger gross margins and smaller costs, the latter having the greater influence.

The study proceeds to group the stores upon the basis of type of farming in the locality, summer and winter dairying and summer dairying. The stores in the summer dairying region appear to have a larger percentage of cash sales and less bad debts, as well as opportunities of operating on higher gross margins and net profits, probably due to the effect of the development of grain grinding services in the businesses.

By classification of the stores by the age of the firm it was found that the older the firm the less efficient it appeared to be, having higher costs and lower profits than the younger firms. The explanation given is that newer methods of operation are adopted by the younger firms which are ignored by those who have been in the business for longer periods.

As stated above, the study is detailed and statistical, the method of analysis and classification adopted being particularly interesting.

J.G.W.

The Bacon Industry; Interim Report by the Pig Industry Council

Marketing Leaflet No. 23. Ministry of Agriculture.

This Report states the Protectionist view of the future of pig-husbandry for bacon production in England and Wales. Producers of fresh pork are in effect receiving protection against imports by the

operation of sanitary regulations. It is only in the bacon trade that expansion in the pig industry can be looked for, but this will require some feeling of security that efficient pig production will yield a reasonable profit. It is postulated that imports govern prices and this first and most vital factor which dominates the whole situation must be given immediate precedence before the Council can feel justified in recommending any steps for the increase of pig production.

"The Council now respectfully urges upon the Minister further consideration of the imperative need for some measure of control, regulation, or restriction of imports of bacon".

A document of opinion. J.G.W.

The Pig Industry in England and Wales

Marketing Leaflet No. 16. Interim Report of the Pig Industry Council. Ministry of Agriculture. H.M.S.O., 1930.

This leaflet contains a brief statement of the more important findings of the Council in the fields of production and marketing. As a condition of future development of the industry an improved economic environment is essential, and this can only be obtained by either reducing costs of production, marketing and manufacture or by maintaining prices artificially. In the sphere of production recommendations are made regarding breeding, recording and litter testing, feeding, management, health and regularity of supplies. Comparisons with the position in competing foreign countries show that the industry in this country is in an inferior position and there is much room for improvement.

On the marketing side reference is made to the more even geographical distribution of the bacon factories in competing countries. Factory supplies and type of cure, grading and misrepresentation of imported supplies are also briefly discussed. The opinion that there is room for economy in the present system of buying and transporting pigs, expressed by the Food Manufacturers' Federation and the National Federation of Meat Traders' Associations is endorsed by the Council.

Whilst economies in production, marketing and manufacture can be achieved the Council is unable to say whether they would be sufficient to put the industry at any advantage compared with European countries. Should the Government desire an immediate expansion, direct Government assistance is in all probability necessary.

In a prefatory statement the endorsement by the Minister of Agriculture of any statements relating to direct Government assistance is withheld. J.G.W.

ANIMAL NUTRITION.

Abstractor:

R. O. Davies, M.Sc., University College, Aberystwyth.

Animal Nutrition; Recent advances in

H. E. Woodman. *Sci. Progress*, 24, 1930, 409-17.

A review of recent work on the following subjects is made: (*a*) pasture herbage, (*b*) mineral constituents of soil and nutritive value of grass, (*c*) beef production, (*d*) nutrition of poultry, (*e*) digestion of cellulose by ruminants, (*f*) the failure of a high protein diet to produce renal disturbance in sheep, (*g*) feeding of pigs with tapioca, sugar beet pulp, and whole sugar beet. R.O.D.

Bacterium Abortus; Effect of Diet on the Resistance of the Albino Rat to Bacterium Abortus

R. HOAGLAND and J. M. BUCK. *J. Agr. Res.*, 1930, 40, 201-8.

Rations deficient in vitamin A, the antineuritic vitamin B, vitamin E, and in calcium and phosphorus respectively, were without significant effect on the resistance of the rat to this organism.

R.O.D.

Calcium; Utilisation of—by the Growing Chick

MUSSEHL, HILL, BLISH, and ACKERSON. *J. Agr. Res.*, 1930, 40, 191-9.

As a basal ration a mixture was chosen that included corn, wheat and milk proteins, and with the particular ration used it was found that calcium furnished as tri-calcium phosphate was more efficiently utilized than was an equivalent amount of calcium furnished as the carbonate, lactate, sulphate, or chloride. R.O.D.

Calves; Metabolism of Nitrogen and Calcium in—during the period of milk feeding

E. A. SOKOLV. *Nauch-Agron.*, Zhur. 6, 429-37 (1929).

In feeding experiments conducted with calves, milk was the basal ration, with no other supplements until the sixth week, when grain and hay were added. The results of the experiments show that the calcium from the milk was more readily utilised than that from the other foods. There were no significant differences in the nitrogen. It is concluded that during the first two or three months of the life of the calf very little calcium is retained from feed other than milk. R.O.D.

Cod Liver Oil of High Acid Content; The toxic properties of

HOLMES, MOORE, and others. *Poultry Science*, 1930, 9, 161.

Experiments were carried out to test the effect of different grades of Cod Liver Oil of varying degrees of acidity on the growth and mortality in chickens. The results definitely show that red cod liver oils of high acid content may contain substances which are detrimental for young chicks. The red high acid cod liver oils used in this investigation caused ruinous mortality. R.O.D.

Dairy Cattle; Results of a five year mineral feeding investigation with

O. E. REED and C. F. HUFFMAN. *Mich. Agr. Expt. Sta., Tech. Bul.*, 105, 3-63 (1930).

The general need for mineral supplements for dairy cattle under normal milk conditions may be greatly exaggerated. Mineral supplements supplying calcium are not greatly needed even when feeds such as timothy and other low calcium roughages are used. Raw rock phosphate should never be fed to cattle because of its detrimental effects, probably due to its fluorine content. Complex mineral mixtures may be harmful if fed over long periods of time. R.O.D.

Dairy Science; Recent Advances in

N. C. WRIGHT. *Agr. Progress*, 6, 1929, 7-22.

A review of recent researches on the protein requirements of cows, relation of dry matter to the digestibility of feeds, physiology of milk secretion and the nutritional value of milk. R.O.D.

Fattening Pigs; The Value of Grazing for

H. R. DAVIDSON. *Scot. J. Agr.*, 1930, 13, 288-93.

In the case of fattening pigs a number of experimental results indicate that when a ration is otherwise properly balanced, the addition of green food makes little, if any, difference. When young pigs are grazed for a few weeks after weaning, however, the advantages of exercise and exposure to fresh air and sunlight lead to an improvement in constitution which is reflected in relatively increased gains when the animals are fattened inside.

Where green foods must be consumed as being the cheapest available foodstuff, it may be fed, preferably cut and supplied in the sties, at a rate not exceeding an average of about 6 lb. per head daily.

R.O.D.

Grass from plots fertilised and grazed intensively in 1929; The Chemical Composition of

J. G. ARCHIBALD. *J. Agr. Res.*, 1930, 41, 491-501.

The effects of fertilizer treatment and close grazing on the chemical composition of grass are considered. A study of the results obtained for two seasons leads to the conclusion that of all the factors that influence the chemical composition of grass, the amount of rainfall is the most important. R.O.D.

Grass; The Protein Content of—as influenced by frequency of Cutting

SHUTT, HAMILTON, and SELWYN. *J. Agr. Sci.*, 1930, 20, 126-34.

From a study of the data of two seasons' work it is shown that the protein content of the herbage increases with the shortening of the period between cuttings. This was due in the first season solely to the fact that the protein content of the grass falls off with age, but in the second and subsequent seasons, in a very large measure, to the incursion of white Dutch clover.

In the second season, when clover replaces grass roughly in proportion to the shortening of the growing period, the higher protein content of the legume tends to counteract the depressing effect on yield of frequent cutting.

In both seasons the largest yield of dry matter was obtained from the plot cut as hay with aftermath. R.O.D.

Honey; Vitamin Content of—and Honeycomb

H. B. KIEFFER and H. E. MUNSELL. *J. Agr. Res.*, 1929, 39, 355-66.

No detectable amounts of vitamin A, B, C, or D were found in any of the honeys or in the honeycomb examined in widely separated localities and representing extremes of colour variation. R.O.D.

Intensive System of Grassland Management; Investigations into the

1. The chemical composition of intensively treated pasture.

A. W. GREENHILL. *J. Agr. Sci.*, 1930, 20, 573-86.

(*a*) Herbage from pastures managed under the intensive systems of grassland management and representing three to five weeks' growth, was closely comparable with that obtained by other workers from pasture cuts at one to three weekly intervals from unmanured pastures.

(*b*) During the grazing season, drought or the early summer flush period produce some reduction in protein content and an increase in

fibre content, with a recovery following the cessation of the drought or after the flush period respectively.

(*c*) The protein content of the dry matter of herbage from pasture receiving intensive manuring including nitrogenous fertilisers, was higher than that from pasture not so treated. Thus the higher milk-producing power of the former pasture may be ascribed in part to improved composition of the herbage as well as to a higher yield of herbage. The bearing of the results on the question of supplementary feeding is discussed. R.O.D.

Iodine Deficiency and Live Stock

C. S. M. Hopkirk and C. V. Dagus. *New Zealand J. of Agr.*, 40, 1930, 226-32.

An account is given of an iodine deficiency disease in lambs in the Cold Lakes region, South Island, New Zealand. Data obtained as a result of investigating the cause of the mortality among the lambs is given. No correlation was found between the iodine content of a soil and that of the pasture grown on it. Some soils, although rich in iodine, give up none to plants. These are generally alkaline soils. Acid soils, on the other hand, give up their iodine very readily to plants.

A deficiency of iodine in the food of an animal reacts on the thyroid gland in such a way that an inverse relationship exists between the size of the gland and its iodine content. R.O.D.

Mineral Content of Upland and Lowland Pastures; The effect of Manures on

T. W. Fagan and A. L. Provan. Welsh Plant Breeding Station, *Publication Series H.*, No. 11.

The results of a pasture experiment conducted at several centres are given. At each centre one plot was untreated, a second received a basal dressing of potash and phosphate, while a third received soluble nitrogenous manures in frequent dressings in addition to the basal dressing. The produce of the plots was cut at monthly intervals. The following conclusions are drawn :—(1) The application of phosphates and potash has resulted in an increase in the average percentage of nitrogen and phosphoric acid content of the herbage at all centres. (2) Though no lime as such was applied to the plots, the addition of phosphates (superphosphate) and potash has resulted in an increase in the average percentage of lime in the herbage of the large majority of plots. (3) The effect of applying nitrogen in addition to phosphates and potash has been to depress the average percentage of phosphoric acid and lime, and at lowland centres if anything to depress even the nitrogen.

R.O.D.

Minerals in the Winter Ration for pregnant and nursing Ewes

D. S. Bell. Ohio Agr. Expt. Sta., *Bimonthly Bull.*, 143, 1930, 38-40.

For three seasons three comparable lots of pregnant and nursing ewes were placed on test. One lot received a basal ration without added minerals, another received per ewe ½ oz. of a mineral mixture (limestone, potassium iodide, common salt, and steamed bone meal), while a third lot had free choice of the minerals. The small amount of potassium iodide prevented goiter or big neck in the lambs at birth. Aside from the goiter problem, if ewes are well fed and the ration contains a liberal

allowance of legume hay, little benefit is derived from the addition of minerals to the winter ration of pregnant or nursing ewes. R.O.D.

Nitrogen Metabolism in Sheep on High Protein Diets; A Study of

J. STEWART. *J. Agr. Sci.*, 1930, 20, 1-17.

The results of this investigation indicate that great care is needed in the conduct of short period balance experiments. Owing to the initial effects which the metabolism cage has upon the animal, at least six weeks should be the allowed in any balance experiment as a pre-period which is to show the normal metabolism of the animal. Another difficulty in short period balance work is the interpretation of the sudden jumps from a high positive to a high negative balance in the course of a few days.

Sheep on a high protein diet first tended to show a nitrogenous equilibrium and then a negative balance. It is pointed out that this must be due to some important factor in the metabolism of a high and excessive protein diet which needs further close enquiry. R.O.D.

Pasture; Nutritive Value of v. Pasture Grass Conservation; The Influence of Artificial Drying on the Digestibility of Pasture Herbage

WOODMAN, BELL, and GRIFFITHS. *J. Agr. Sci.*, 1930, 20, 53-62.

It is shown that young grass does not suffer any depression in respect of digestibility when it is dried (*a*) at the temperature of steam, or (*b*) by direct heat in a kiln. R.O.D.

Pasture; Nutritive Value of—VI. The Utilisation by Sheep of Mineral Deficient Herbage

H. E. WOODMAN and R. E. EVANS. *J. Agr. Sci.*, 1930, 20, 587-617.

The results of this investigation lead to the belief that the failure of stock to thrive in mineral deficient pastoral areas cannot be explained by assuming that the low mineral content is responsible for a lack of palatibility in the herbage and a consequent depression of appetite in the grazing animals. Neither is there any evidence that the shortage of minerals causes the herbage to be digested any less efficiently than "normal" cultivated herbage of similar maturity and organic composition. The amount of net energy which ruminant animals are able to derive from any form of herbage seems to be independent of the mineral content and to depend solely on the amount and character of the organic constituents.

Malnutrition on pasturage of sub-normal mineral content is due directly to the failure of the diet to supply the necessary inorganic materials for constructional and other purposes. R.O.D.

Pigs; Reproductive Disturbances caused by feeding Protein-deficient and Calcium-deficient Rations to Breeding

H. R. DAVIDSON. *J. Agr. Sci.*, 1930, 20, 233-64.

Evidence is submitted to show that

1. Partial foetal atrophy in sows is not due to a deficiency of protein in the ration.

2. Calcium deficiency is not the major factor in producing this type of foetal atrophy though it may be a contributory cause.

3. None of the evidence obtained disproves the conclusions of other workers that foetal degeneration of a partial nature is probably caused by factors inherent in the zygote itself.

4. Definite evidence was obtained that a calcium deficient diet leads to a very considerable increase in the number of pigs born dead. It also leads to a very serious reduction and eventual failure of the sow's milk supply. R.O.D.

Potatoes and Oats; The Use of—as Feeding Stuffs

ROWETT INSTITUTE CONTRIBUTION. *Scot. J. Agr.*, 1930, 13, 30-43.

For cattle potatoes can be fully utilised raw, but for pigs the percentage utilisation is increased by cooking. For young pigs crushed oats can be used up to one-third of the ration without harmful effects. The results of tests show that for young pigs, rations containing a high proportion of oats and boiled potatoes give as good gains and are more economical than rations with certain other commonly used feeding stuffs. For milk cows oats, if balanced up with a protein rich feeding stuff and a mineral mixture, can be fed up to 75 per cent. of the production ration. Potatoes can be used up to 12 lbs. per head per day with beneficial results. R.O.D.

Potassium Iodide as a Mineral Supplement for Growing Swine

CARROLL, MITCHELL, HUNT. *J. Agr. Res.*, 1930, 41, 65-77.

In a pig feeding experiment no evidence was obtained that the administered potassium iodide, equivalent to 1 gram of iodide daily, in any way affected the rate of growth. R.O.D.

Potassium Iodide; Influence of small quantities of—on the Assimilation of Nitrogen, Phosphorus and Calcium in the growing pig

McCLURE and MITCHELL. *J. Agr. Res.*, 1930, 41, 79-87.

In metabolism experiments upon five pigs, there was no evidence that the utilisation of either nitrogen, calcium or phosphorus was favourably affected by potassium iodide. There was some indication that the retention of calcium was adversely affected. No effect of the iodide administration on the rate of growth of the pigs was evident. R.O.D.

Poultry; Nutritive Requirements of. VII. Growth in Chickens

ROBERTSON, ORR, PRENTICE and MACDONALD. *Scot. J. Agr.*, 1930, 13, 410-5.

The experiments described indicate that a supplement of salt (NaCl) is essential for adequate growth and health in chickens fed on a ration of cereals and soya bean meal.

Under the conditions of these experiments, sulphur, iron oxide and potassium iodide can be omitted without any bad effect. It is, however, possible that under different conditions, or in different districts, a different result might have been obtained. Consequently it will be necessary to repeat the tests at different centres. R.O.D.

Sodium Chloride in the Nutrition of Stock; its action upon Nitrogen Metabolism

E. F. TERROINE and T. REICHERT. *Compt. rend.*, 190, 1930, 768-70.

Rabbits, sheep and hogs were fed on a basal diet corresponding to their normal food habits and subsequently on a diet to which sodium

chloride was added, and during the final period on the basal diet. Nitrogen retention was always improved during the period in which sodium chloride was added to the diet. This indicates that the mineral content of the diet is a factor in the utilisation of protein R.O.D.

Suckling Pigs; The Production and Cure of Nutritional Anemia in

HAMILTON, HUNT, MITCHELL and CARROLL. *J. Agr. Res.*, 1930, 40, 927-38.

There is a rapid decrease in the hemoglobin concentration of the blood of pigs during the first few days after birth. In the case of litters remaining indoors the decrease in the level of hemoglobin in the blood continued until concentrations of 4, 3 or even 2 gm. per 100 c.c. of blood was reached. In the case of litters removed outdoors, this decrease was stopped and an increase was induced, until the birth level of hemoglobin was again reached. The birth level of hemoglobin could also be restored by administering ferric citrate and copper sulphate to the pigs. R.O.D.

Swine; The Influence of a Low and High Calcium Diet on the Development and Chemical Composition of the Skeleton in

R. E. EVANS. *J. Agr. Sci.*, 1930, 20, 117-25.

The skeletons of young pigs on a ration composed mainly of cereal grains but with the addition of cod liver oil show a very distinct lack of calcification, the percentage of ash being about 12 per cent. lower than in the bones of normal animals. A difference of about 360 gms. tricalcic phosphate was found between the same mature bones of normal and calcium deficient animals. The main characteristic of the bones in low calcium rickets is a low ash content, but the composition of the ash is normal. R.O.D.

LIVE STOCK.

Abstractors:

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Angora Rabbits; The Inheritance of Head Furnishings and Wool Quantity in (Die Vererbung von Haarbüscheln und Woolmenge bei Angora-Kaninchen)

J. N. PICKARD. *Züchtungsk.*, Vol. 5, pp. 339-51, 1930.

Angora rabbits may exhibit what are called " head furnishings ", *i.e.*, tufts of wool at the end of the ears, or on the other hand the ears may be free from wool. Breeders are of the opinion that head furnishings are correlated with high wool production. This paper records the results of breeding experiments which point to the fact that head furnishings, together with high wool production, depend upon a single dominant Mendelian factor. It is considered probable that further modifying hereditary factors may contribute to the fine distinctions in the development of these characteristics. J.A.F.R.

Autosomal Linkage in the Domestic Fowl; Further Data on a Case of
L. C. DUNN and W. LANDAUER. *J. Genet.*, Vol. 22, pp. 95-101, 1930.

Evidence is brought forward to show that the genes for three characteristics are carried on the same autosomal chromosome pair. The characteristics are dominant white plumage, cerebral hernia, and polydactyly. These last two are features which are variable in their expression, and the precise strength of the linkage is therefore not easy to estimate. It is probable, however, that the factors for dominant white colour and hernia lie very close together and the factor for polydactyly relatively distant from them. J.A.F.R.

Bang Abortion Disease in Cattle and Swine; Investigations on the
J. W. CONNAWAY. *Abs. in Miss. Agr. Exp. Sta. Bul.*, 256, pp. 97-100, 1927.

The object in this experiment was to find out whether the progeny of animals infected with the Bang Abortion bacteria were themselves likely to be infected. Although each calf of an infected dam remained with its mother continuously during the full lactation period and imbibed the infected milk at will until weaned naturally, they did not appear to have received any *permanent* infection. The positive antibody reaction of the blood of the calf in every case disappeared before the advent of sexual maturity; in no instance did one of the calves of the infected cows acquire permanent infection after reaching sexual maturity, although exposed at pasture to the infected and positive infected dams and grandams. Thus we find convincing proof that the progeny of the relatively immune abortion-infected cows can, by proper management, be reared under practical farm conditions to maturity without acquiring a permanent infection with the Bang Abortion bacterium from the infected dams. A.D.B.S.

"Blackface Sheep"; Observations on—Their Origin and History.
A. E. PEASE. *J. Yorks. Agric. Soc.*, pp. 5-22, 1930.

This paper develops an interesting hypothesis with regard to the ancestry of domestic sheep in general and the Blackface breed in particular. The author considers that the common ancestor of sheep and goats must have been an animal resembling the present-day Bharal, a type found in the high mountains of the inner Himalayas and Tibet. From this stock spring three families, the Argali family and the Urial family of sheep, together with the Tur family (goats). The Argali family he regards as being closely allied with the American Bighorns. This family as a whole does not contribute to the development of domesticated breeds. These are entirely attributed to the Urial family. Here *Ovis vignei arkal* is regarded as coming closest to an ancestral type which has given two diverging groups. Through sheep of the *vignei* type, dating from about 7,000 B.C., come the Turbury sheep, ancestral to Cretan sheep and other domestic types, also the Barwal and Hunia, in which line of descent are to be found the Persian, Arabian and Somali sheep with also the European Blackfaced horned sheep, which through the Danish Heath sheep give the Blackface and the Old Norfolk breed.

To return to *Ovis vignei arkal*, the second group derived from this type gives the Mouflon family, and through *Ovis musimon* and *Ovis orientalis* are derived sheep such as the Soay and many other domestic forms.

The sharp distinction between the two groups of domestic sheep is an interesting one, and the author suggests that the Urial family arrived in Great Britain from Asia and then Eastern Europe by way of Denmark with the Danish invasions.

The whole hypothesis is presented in a very clear chart.

J.A.F.R.

Blood Groups in our Domestic Animals (Über das Vorkommen von Blutgruppen bei unseren Haustieren).

S. SCHERMER. *Deutsche Tier. Wochen.*, Vol. 36, pp. 797-802, 1928.

This is an important paper. It has already been shown that in the human, blood composition is inherited along very definite lines and that the various blood groupings have a direct bearing on susceptibility or resistance to disease. In this paper the whole subject is reviewed and data on sheep, cattle, pigs and horses are given.

Working with sixty sheep, the author confirms the results of previous investigators- Bialosuknia and Kaczkowski. The blood reactions were divided into three groups and a description of each is given pending a more detailed account.

The reactions in goat's blood were so irregular that they could not be divided into a group scheme, though they showed a close relationship to those of the sheep.

Previous work showed isoreactions in the pig, three groups being found which are analogous to those in the sheep. The reactions in the pig were clearer than in any other animal. The blood of the pig closely resembles that of man.

It is, however, with the horse that the author deals most fully, and finds that there are four main groups which in their behaviour react to each other in the same way as do the four main groups in the human. Furthermore, just as in man the various races show varying proportions of the different blood groups, so also in horses the thoroughbred type have a greater proportion of group one and none of group four, while the heavy type have a smaller proportion of group one and a few of group four. The horse, in contrast to all other animals, apparently shows a more far-reaching differentiation as regards the accessory groups.

A.D.B.S.

Bovine Quadruplets

F. B. HUTT. *J. Hered.*, Vol. 21, pp. 339-48, 1930.

The birth of quadruplets in cattle must be an exceedingly rare event. In one comprehensive study quoted by the author a single case only was found amongst nearly 750,000 births.

All four calves were reared; one was a bull which was normal and produced calves; one was a free-martin heifer; while the remaining two were heifers and were sterile, therefore in all probability free-martins showing less abnormality than their sister. A considerable amount of evidence is brought forward to show that this last pair were true monozygotic twins, the occurrence of which in cattle must at best be excessively rare. In addition to great similarity of many characteristics there was a reversed asymmetry or " mirror-imaging " in their black and white colour patterns. An examination at the time of birth of the fœtal envelopes indicated that in all probability the two heifers were enclosed in a common chorion in one horn of the uterus.

J.A.F.R.

Breeding Capacity in Breeding Cattle; On Criteria for

J. W. GOWEN. *Amer. Soc. Anim. Prod., Rec. Proc. Annual Meeting*, 1929, pp. 47-9, 1930.

The author finds that the best index of a sire's breeding capacity yet discovered is the production or butter-fat percentage of his daughters, corrected for age. If this index is combined with the record of the cow to which he is mated the correlation is still better.

J.A.F.R.

Breeding for Milk

J. HAMMOND. *Year Book of the Central Council of Milk-Recording Societies*, 1930.

The author considers that while existing practices in animal breeding have been very effective in developing the beef breeds of cattle, it cannot be said that they have been equally effective in developing milk production. This is largely due to the fact that it is not an easy matter to assess the value of a dairy bull. In view of the short time that systematic milk recording has been in operation, not very much information can be obtained from a study of pedigrees. The progeny test is a better guide. The super premium system for proved sires is advocated. It is suggested that inbreeding is not being used freely enough in the building up of strains of good milk producers. It is undoubtedly the case that different types of cattle are suited to different localities, and the effort should be made to develop breeds and strains suitable for particular environments. J.A.F.R.

Butter-Fat Percentage in Crosses of Jersey with Red Danes; The Inheritance of

C. WRIEDT. *J. Genet.*, Vol. 22, pp. 15-63, 1930.

It is usual at the present time to refer quantitative differences that are based wholly or in part upon inheritance to multiple factors. Frequently this is done after an analysis of the variability of an F_1 and an F_2. The late Christian Wriedt, in his numerous studies on farm animals, discovered a remarkable number of single factor differences, and in this paper he attacks the facile application of a multiple factor hypothesis to problems of quantitative inheritance, and states that in many cases this explanation is based upon a misinterpretation of the data. He comes to the conclusion that crosses between the Jersey and Red Danish breeds show that the difference in butter-fat content in the milk of the two breeds is due to a single Mendelian difference, and that this factor, although it varies in its effect, exerts the same influence upon either high or low percentage butter-fat. In addition it is possible that some of the Jersey bulls used in the experiment had a modifying factor which caused an increase in butter-fat percentage, but the existence of this factor is not yet conclusively proved.

J.A.F.R.

Colour Inheritance in Sheep—IV. White Colour, Recessive Black Colour, Recessive Brown Colour, Badger-face Pattern, and Reversed Badger-face Pattern

J. A. FRASER ROBERTS and R. G. WHITE. *J. Genet.*, Vol. 22, pp. 165-180, 1930.

White colour is due to a dominant inhibiting factor. In the absence of this factor the sheep is either black or brown. (These colours are termed " recessive " because of their relationship to white). In all

probability a single Mendelian factor difference separates recessive black from recessive brown, but the precise relationship is not known because brown is the bottom of a series. The two patterns are each associated with a dominant factor, which in each case affects recessive black or recessive brown, but produces no effect in the white sheep. If both factors are present simultaneously that for badger-face pattern alone is expressed. J.A.F.R.

Colour Inheritance in Sheep—V. Dominant Black

J. A. Fraser Roberts and R. G. White. *J. Genet.*, Vol. 22, pp. 181-90, 1980.

Further observations are presented on dominant black colour. It is possible that more than one dominant black factor exists. The badger-face and reversed badger-face factors produce no effect on the dominant black sheep. The Mendelian factors discovered in the sheep up to the present time are as follows:—

(1) Dominant black.

(2) Dominant brown.

(3) White.

(4) Recessive black.

(5) Recessive brown.

These colours form what is known as an epistatic series, that is, they depend upon separate factors, the presence of any factor inhibiting the expression of factors lower in the series. The main modifications of these basic colours are as follows:—

(1) A recessive piebald factor which in the duplex state turns dominant black into piebald. Effect on the other colours not known. No effect on white. (Piebald of Spanish breed).

(2) A factor which in the duplex state turns dominant black or dominant brown into black-headed pattern; in the simplex state into a form of piebald. Effect on recessive colours not known.

(3) The badger-face factor, which in the duplex or simplex state turns recessive black and probably recessive brown into badger-face pattern. No effect on white or dominant colours.

(4) The reversed badger-face factor, which in the duplex or simplex state turns recessive black or recessive brown into reversed badger-face. Can only be expressed in the absence of the badger-face factor. Has no effect on dominant colours or on white.

Other modifications are:—

(1) A white patch on the top of the head and a white tip to the tail -a dominant factor subject to much modification.

(2) Varying amounts of white on the faces and legs of black sheep appear to depend upon a series of multiple factors. Probably they do not affect dominant black.

(3) A dominant factor which in coloured sheep produces a white collar. Expressed in dominant or recessive blacks.

(4) Two factor pairs which affect amount and distribution of pigment on the face and legs of white-fleeced sheep. Do not affect coloured sheep.

(5) A dominant factor which turns black into grey, the lambs being born grey. J.A.F.R.

Cows' Milk; Size of Fat Globules in

C. W. TURNER and A. C. HASKELL. *Mo. Sta. Res. Bul.*, No. 130, 1930.

From this study it would appear that fat globules of the Jersey breed were considerably larger than those of the Holstein, while Ayrshires are smaller still. A.D.B.S.

Creeper Fowl; Studies on the—I. Genetics

W. LANDAUER and L. C. DUNN. *J. Genet.*, Vol. 23, pp. 397-413, 1930.

There is a growing literature of simple Mendelian abnormalities which produce a deformity in the heterozygous animal, but where the homozygous form shows yet more marked abnormality and is lethal. The Creeper breed of fowls is a particularly interesting case of this type. In these fowls there is an extreme shortening of the long bones of the extremities, a more or less striking bending of the tibia, and a highly differentiated fibula. The authors conducted breeding experiments with four different strains of Creeper Fowl, obtained from America, Germany, Scotland and the Marquess Islands. It was found that the Creeper traits are determined by a single dominant Mendelian factor, which is lethal in the homozygous condition. The lethal nature of the homozygous condition was demonstrated by the fact that breeding tests showed that only heterozygous animals existed, that in matings of Creeper to Creeper two Creepers to one normal were produced, and by the fact that approximately 25 per cent. more embryos died in such a mating than in outcrosses. The characteristic lethal period is at the beginning of the fourth day of incubation. At 72 hours there is a striking retardation in growth and differentiation. A small proportion of homozygous embryos in crosses of the original stocks with themselves, and a considerably larger number in crosses between different Creeper lines, survived the typical lethal period. Such embyros exhibited a malformation closely resembling or identical with phokomelia in humans and other mammals. They usually die during the last week of incubation, but in rare instances are still alive at hatching time. They never hatch. It is also shown that even the heterozygous Creeper condition is of a slightly semi-lethal nature. Crosses between the different Creeper lines appear to show that the condition in all four strains was due to one and the same mutation. J.A.F.R.

Dairy Cattle; Size in

J. C. MCDOWELL. *U.S. Dept. Agric. Circ.*, 114, 4 pp., 1930.

A study of the yearly individual records of nearly a quarter of a million cows revealed that in general within the same breed the heavier the cow the greater the total yield of milk and the greater the yield of milk per pound of food consumed. While the larger animals had more than the smaller ones the increased consumption was not in proportion to the increase in production of milk. The conclusion is reached that, other things being equal, a large cow will produce more milk and return a greater profit than a small cow. A.D.B.S.

Dairy Cattle; Studies in

Illinois Sta. Rep., 1929. *Abs. in Exp. Sta. Rec.*, Vol. 62, pp. 323, 369 and 370, 1930.

Studies and observations by W. W. Yapp on approximately 500 animals produced in the Bowlker herd, which was established by crossing

Holsteins and Guernseys, indicated that milk yield, percentage of butter-fat, protein and ash in the milk, and conformation, were hereditary characters controlled by a considerable number of factors, ten being suggested for milk yield. The percentage of lactose in the milk was similar for the two breeds. The size of the animals was in part hereditary and in part environmental.

There was evidence that the open or protruding shoulder was an inherited character controlled by the operation of one or two factors. Variability in this characteristic was, however, influenced by the type of stanchions used.

Skin colour and colour of the secretions were hereditary but were difficult to study on account of the high correlation with the amount of green feed consumed. No positive correlation was found between colour of skin pigment and colour of milk fat in dairy cattle by W. W. Yapp and A. F. Kuhlman. The colour of the skin pigment of the heavy-producing cows was greatly depleted when they did not receive enough green feed. Calves of highly pigmented breeds did not show the same amount of pigmentation as older animals until fed with green feed.

Yapp applied the formula $x = 2a - b$ (in which x equals the sire's transmitting ability, a the record of a given daughter, and b the record of the dam of that daughter) to the daughters of Jersey, Holstein and Guernsey sires. When a sire was able to transmit production to his daughters equal to the average production of cows of his class, he was considered to have 100 per cent. transmitting ability. Among the twenty-five Holstein sires studied, the best bull showed a transmitting ability of 265.6 per cent., while the poorest bull had only 89.4 per cent. transmitting ability. Of the Jerseys studied, the best bull showed 185.1 per cent., and the poorest bull 76.2 per cent. transmitting ability.

W. L. Gaines and J. H. Brook, using the fat yield for the first full month of advanced registry cows of the Brown Swiss breed, found the average persistency for 365-day records of this breed to be 97. The records show that persistency is not affected by age, but that it is greatly affected by the rate of yield.

A.D.B.S.

Domestic Dog; Genetic Studies on the

T. Marchlewski. *Bull. de l'Acad. Polon. d. Sci. et des Lettres*, pp. 117-145, 1930.

As regards shape of head in dogs, there is a general suggestion that the broad type is recessive to the long type of the greyhound or collie. Specific modifying factors appear to be present, and there is the suggestion of multiple allelomorphism. The type of body conformation appears to show segregation. Certain mental characteristics also appear to segregate, and independently of bodily conformation. This applies to " pointing ". The style of hunting with the head held high appears to be dominant to the type of hunting in which the head is held close to the ground. The silent hunting typical of the Pointer also appears to be dominant. There is a comprehensive review of coat colour in the dog and comparisons are made with other mammals.

J.A.F.R.

Dry Cows

H. G. SANDERS. *J. Min. Agr.*, Vol. 37, pp. 928-32, 1930.

In his notes on feeding stuffs in the December issue of the Journal of the Ministry, Dr. Sanders explains at some length the practical results of the dry period for dairy cows. He is of opinion that where possible the dry period should be from six to eight weeks, but he points out that persistent and non-persistent cows react very differently to the dry period. The cow which is a persistent yielder is very severely handi capped by a complete absence of rest but gains practically nothing by a rest longer than one of six weeks. A dry period of less than a fortnight for the persistent cow has a disastrous effect on the yield of the cow's lactation, while there is not a great deal to be gained by giving anything over six weeks.

With the non-persistent cow it is a different story. Such a cow gives a high daily yield of milk shortly after calving but this quickly dries up. With such a cow if she is given no rest the subsequent lactation is not nearly so badly affected as if she were a persistent yielder. All the same if she is given a rest of three months she will give in her subsequent lactation a greater yield of milk than if she were only given a rest of four or six weeks. The longer the rest period for the non-persistent cow the better would be the yield in her subsequent lactation.

Dr. Sanders points out that it is probable that with the persistent milker the chief factor is the growth of the gland but that with the non-persistent milker it is search of food. The persistent milker is the true dairy cow which always tends to put the food in the pail rather than on her own back.

Whether it will pay to give a short or a long rest cannot, of course, be stated dogmatically. In any case, as Dr. Sanders points out, the decision of the question does not commonly arise, for this type of cow helps herself to plenty of rest by drying off some time before calving. This is the type of cow that will respond best to the "steaming up" process, which will help her in the direction in which she is weakest, that is to say, in keeping up her yield after the flush is past. With the naturally persistent cow it is rest rather than "steaming up" that is required; feeding during the dry period in her case will be good as far as it makes good her losses if she is in poor condition. A.D.B.S.

"Duck-legged" Cattle on Texas Ranches

J. L. LUSH. *J. Hered.*, Vol. 21, pp. 85-90, 1930.

At the Southwestern Livestock Show and Exposition at Fort Worth in March, 1927, there was exhibited in one of the beef calf classes open to club boys an extremely short-legged calf. Investigations into the origin of this animal disclosed a most interesting story in the history of breeding. It is probable that all the short-legged animals now to be found in various Texas herds trace back to a single origin or importation, and it is also possible that this is the same condition as that found in the Dexter breed. The abnormality appears to be confined to the shortness of the legs, though possibly there is some shortening in the length of the body. The heads appear to be entirely normal, and in spite of careful questioning no cases of the birth of "bull-dog" monsters such as occur in the Dexter breed could be discovered. An

examination of the glands of the endocrine system revealed no abnormality except in the pituitary, which was of small size. Animals of this type compare favourably with normals as beef producers.

It is certain that the history of the type in Texas goes back for a great many years, though several versions of their origin and spread are current. One states that two black heifers with white spots were brought from Louisiana to Texas in 1879 or a few years later by a Colonel Parramore. Another account states that Col. Parramore obtained them near Gonzales, Texas, where they or their parents had been brought from a ranch in the extreme south of that State, to which a few Kerry cattle had been imported direct from Ireland in the early seventies. However, the present owner of that ranch states that the first he saw were in 1884 or 1885 in a herd which was being pastured for another man. Some of these were bought and a few were bred for many years. Several other people bred them at one time or another in south Texas. A less circumstantial account is to the effect that they were brought from France by early settlers along the coast country of Texas south and east of Gonzales. When Col. Parramore went to Runnels County the modern beef breeds had hardly begun to find their way to the ranches, the customary procedure being to save for breeding the best looking bull calves of the rancher's own raising, little or no attention being paid to colouring. Many duck-legged bulls were saved in this way. When improvement with the modern beef breeds began there were many duck-legged cows left, and these produced a number of duck-legged daughters, which were kept. The numbers, therefore, diminished but slowly, while several generations of pure-bred Hereford bulls were being used. The result has been the development of a type of duck-legged animal almost indistinguishable from pure Herefords except in this peculiar feature. The strain was perpetuated by the use from time to time of a duck-legged bull mated to normal cows.

It seems fairly clear that the characteristic is inherited as a simple Mendelian dominant.

The whole story is of great interest, not only as the history of an adventure in breeding, but because of the additional information it provides on achondroplastic conditions in cattle. The close correspondence between this abnormality and the Dexter type of configuration, combined with the fact that in this case "bull-dog" calves do not appear, is a confirmation of the hypothesis advanced by Crew, who suggested that while there might be a single dominant factor for dwarfness, two additional modifying factors were present in the Dexter breed which intensified the dwarfness, the presence of all three factors giving rise to the Dexter monster. The repeated outcrossing in Texas would result in the retention to all intents and purposes only of the main dominant factor. The observation that the pituitary is abnormally small in these animals also lends confirmation to the hypothesis advanced by Crew that pituitary malfunctioning is originally responsible for this condition.

J.A.F.R.

Earlessness in Karakul Sheep

J. L. Lush. *J. Hered.*, Vol. 21, pp. 107-12, 1930.

In Karakul sheep the short-eared condition appears to be relatively common, and the interbreeding of sheep of this type gives a proportion of animals practically devoid of any external ear, and therefore termed

"earless". Ritzman and Wriedt, working on different material, both discovered that a single Mendelian factor was involved, with intermediate inheritance, the normal long ear and the earless condition being the homozygous forms, and the short-eared condition the heterozygous form. Further data included in the present paper fully confirm these conclusions. J.A.F.R.

Fecundity of Swine; The Normal Sexual Cycle, and as Influenced by Unfavourable Dietary Conditions

A. G. HOGAN and F. F. MCKENZIE. *Abs. in Miss. Agr. Exp. Sta. Bul.*, 256, pp. 46-7, 1927.

There are very marked changes in the genital tract of the sow from one heat period to the next. It was found that keeping gilts on the medium and low planes of nutrition had the result of delaying the first pig crop by over two months as compared with well-fed gilts. Early breeding has not meant much retardation of the growth of sows so long as they were well fed and well cared for. Continued early breeding for eighteen years has not detrimentally affected the ability of the later generation sows to wean heavy pigs. The first month after a sow has been successfully mated appears to be an important time to maintain the gaining condition of the animal. When sows gained below the average for the group during the first month after being bred they produced litters below the average in size at birth and at weaning time.

A.B.D.S.

Fowl; The Genetics of the—I. The Inheritance of Frizzled Plumage

F. B. HUTT. *J. Genet.*, Vol. 22, pp. 109-27, 1930.

Fowls; The "Frizzle" Character of.

W. LANDAUER and L. C. DUNN. *J. Hered.*, Vol. 21, pp. 291-305, 1930.

These two papers record the result of independent investigations which have led to the same conclusions. The Frizzle is a well-known breed, in which the feathers have the appearance of having been rubbed the wrong way. It is well known that Frizzles bred together always throw a proportion of normally feathered birds, and for this reason it has been widely assumed that a single factor pair is involved and that the homozygous frizzled bird is non-viable. These two investigations have shown that the difference between frizzled and non-frizzled plumage does depend upon a single factor pair, but that the homozygous condition of the factor is not lethal. Homozygous frizzled birds can be produced, but the peculiarity is much exaggerated in these cases, so that the birds would be regarded as useless for exhibition and breeding purposes. The result is that only the heterozygotes would be selected by breeders and would of course when interbred give a proportion of normals. Although the Frizzle characterisation cannot be regarded as lethal, those birds with an extreme frizzling do tend to show a reduced resistance to adverse environmental conditions. There appears to be a high rate of embryonic mortality, and this is explained by deficiencies in the storage material of the eggs due to the necessarily increased basal metabolism of the mothers. J.A.F.R.

Genetic Studies in Poultry—VIII. On a Case of Sex-Linkage within a Breed

R. C. PUNNETT and M. S. PEASE. *J. Genet.*, Vol. 22, pp. 895-7, 1930.

Professor Punnett and Mr. Pease have, in an exceedingly modest manner, announced in this paper the discovery of a point that should be

of considerable interest to poultry breeders in the future. Their work is based on these two facts. First, that the Plymouth Rock type of barring in poultry which is dominant to self-colour is sex-linked, and secondly, that the Hamburg-Campine type of barring which is recessive to self-colour is not sex-linked. Plymouth Rocks were crossed with Gold Campines, the crosses with the dominant barring were then mated back to pure Gold Campines. By this means mixed barred birds of both sexes were obtained and mated. Altogether, one quarter of the offspring were normal Campines, half of them were like their parents and about a quarter showed a very much paler down. These last were all males, whereas the normal Campines were all females. The result of all this is that the writers have obtained within one breed animals which show as day-old chicks a difference in plumage according to their sex.

A.D.B.S.

Hen-Feathered Brown Leghorns by Breeding; The Production of.

M. A. Jull and J. P. Quinn. *J. Hered.*, Vol. 21, pp. 177-86, 1930.

In hen-feathered breeds of fowls the plumage of the male, instead of showing typical secondary sexual differences as contrasted with the female, is of the female type. It has been held to behave as a simple Mendelian dominant in inheritance. Extensive breeding experiments by the authors confirm that general conclusion but suggest that additional modifying factors are involved. J.A.F.R.

Horse; The Genetics of the

F. A. E. Crew and A. D. Buchanan Smith. *Bibliogr. Genet.*, Vol. 6, pp. 123-70, 1930.

This paper is a comprehensive review of the subject and includes a bibliography of 8½ pages. The difficulty in treating the genetics of the horse is that a large number of records exist, but they are based mainly on entries in stud-books, which are subject to a certain degree of error. Nevertheless, particularly as regards colour and markings, many deductions can be drawn. Chestnut, black, brown and bay are closely related genetically. There is general agreement that chestnut is recessive to the three others. Black also appears to be recessive to brown and to bay. The series is not one of multiple allelomorphs, and the simplest explanation, which is adopted here, demands two pairs of factors. In the case of the first, the dominant member corresponds to black, the recessive to chestnut. The dominant member of the second pair is a modifier of black producing brown and bay, but with no effect upon chestnut. Light chestnut behaves as a simple recessive to chestnut. The relationship of brown and bay is complicated by the fact that the two colours are often not sharply distinguished. Until critical experiments have been carried out the simplest view would be to hold that brown is a simple recessive in relation to bay and that light bay is the result of a modifying factor acting upon bay. Grey is due to the action of a factor which is dominant in relation to the four colours already mentioned. Roan is also due to a factor dominant to the four self colours. The relationship of grey to roan is obscure. A general sprinkling of white hairs over the body appears to be a dominant. A similar characteristic in the case of the Clydesdale would seem to be recessive, but data are slight. Dun is due to the action of a factor dominant to the four self colours and it is recessive to grey. The exact shade of the dun is determined by the basal

colour of the coat. White is partially dominant to all other colours including grey, roan, and dun. The homozygous white animal is white with coloured points, while the heterozygote may be dirty white or light grey. It is possible that one type of cream is of this nature. According to Wriedt there is a suggestion of sex limitation, in that all the grey-whites he encountered were females. Albino white is recessive to all colours. White markings (as distinct from piebald) show considerable variability, and may be due to a main dominant factor. The piebald or skewbald characteristic behaves as a simple dominant, transforming any basal body colour into the piebald character. The marking called by Wriedt " Pinselhaar " is a simple dominant. Dark spots covered with black hairs are found on the cheeks. The presence of " tiger spotting " is dominant to its absence. Another type of " tiger spotting " appears from scanty data to be recessive. In the case of zebra markings more than one factor appears to be involved. Strong furnishings, that is, hair above the hoof, prove to be dominant over their absence in the East Prussian breed, but in crosses of the Shire and Clydesdale inheritance is intermediate. Fine head is said to be dominant to coarse, and convex nasal bones to concave. The Arab horse is said to possess only five lumbar vertebrae, and this characteristic is inherited as a recessive. Polydactyly is of frequent occurrence but its mode or inheritance is unknown. Doubt is thrown upon the suggestion that pacing is a simple recessive as against trotting. Studies on body conformation are not readily susceptible to genetic analysis. Schermer states that there are four blood groups in horses, their interaction being similar to those found in man. Racial differences exist. There are genetic influences affecting fertility and sterility.

As regards pathological characteristics, many of these have been claimed to be inherited. Wall-eye in the Clydesdale is recessive and appears to be associated with colour. Osteoporosis is stated to be a simple dominant. In the English thoroughbred racehorse there is a recessive character which results in fragile blood-vessel walls in the homozygous condition. Atresia coli, a lack of development of the intestine in the region of the ascending colon, behaves as a simple recessive. Stringhalt, shivering and whistling are probably inherited. Roaring is in all probability a simple recessive.

Although it must be an excessively rare phenomenon, there appears to be little doubt that occasionally fertile mules can be found.

J.A.F.R.

Inbreeding in Sheep

E. G. Ritzman. *New Hampshire Sta. Bul.*, No. 250, pp. 20-1, 1930.

These sheep were inbred for fifteen years during which no outside blood was introduced for seven generations, with the result that there was a decrease in size even with constant elimination of the small-sized individuals. There was, however, no reduction in fertility and the percentage of twins increased. Further studies indicated that higher milk-yielding capacity was associated with the multinipple characteristic, but few individuals have been produced with more than two functional nipples.

A.D.B.S.

Inheritance of Coat Colours in Crosses; Studies on the—involving Philippine Native with Hereford and Nellore Cattle—Preliminary Report.

M. MANRESA, B. M. GONZALEZ, F. B. SARAO, and J. P. ESGUERRA. *Philippine Agr.*, 18, No. 9, pp. 521-38, 1930.

Studies of colour inheritance in crosses between Hereford and Nellore, Nellore and native, and Hereford and native cattle indicated that the Nellore cattle and the native Philippine cattle carry the factor for black and a dominant factor which dilutes black and red to dun and yellow. A factor—*A*- for silver grey is carried by the Nellore breed. When homozygous this characteristic is completely epistatic to black and red, but when heterozygous partial expression of these colours is permitted. Brindling in cattle is due to a dominant factor. This may be carried by Herefords without expression, since the breed does not carry black. A.D.B.S.

Measuring the Influence of Hormone and Mechanical Stimulation by means of a Non-Fecund Lactation

R. B. BECKER and P. C. MCGILLIARD. *J. Dairy Sci.*, Vol. 13, pp. 372-9, 1930.

Rosa Segis Johanna is a 2,000 gallon Holstein-Friesian cow. A month after she calved for the fourth time a nail was discovered in her stomach and she had to be operated on for its removal. She recovered from this operation and continued to give a good yield of milk, going dry 338 days after calving. It was then found that she could not be successfully mated up again, despite various methods which were applied to induce fertility. She went dry on August 17th, 1925, but her udder began to develop in June, 1926. Stimulation of the udder and teats brought the cow into milk and for thirteen months she was milked twice daily. Conception occurred only twenty-four days prior to the completion of this remarkable non-fecund lactation. The interesting part about this cow is that it discriminates the part played by pregnancy from that played by other factors in the promotion of milk yield. The curve of the non-fecund lactation is compared to those of two preceding and one subsequent normal lactations. At the peak of production, following normal reproduction, the total daily milk yield was from 3½ to 5 times as great as in the case of the non-fecund lactation. From the length of this abnormal lactation it may be gathered that the internal stimulus is not necessarily a factor in determining the persistency of milk flow as indicated by the duration of the lactation period. A.D.B.S.

Milk Secretion; The Inheritance of Body Weight in Relation to

C. W. TURNER. *Miss. Agr. Exp. Sta. Res. Bul.*, 147, 1930.

It has for some time been known that the size of a cow has a direct bearing upon the amount of milk she will give in a lactation. A comparison of the changes in body weight and yearly fat production between dams and daughters indicated that Jersey sires can cause significant changes in yearly fat production (either upward or downward) of their daughters as compared with their dams without causing a material increase or decrease in body weight. It was found that for each increase of 100 pounds in body weight of the dams there was an increase of about 16 pounds in body weight of the daughters. It was also found

that there was an increase of approximately 20 pounds in yearly fat production for each 100 pounds increase in body weight above 842.3 pounds. (The same author in a previous paper working with Guernseys found that an increase of 100 pounds live weight was followed by an increase of 20 pounds in butter fat under the same conditions). The writer gives a formula for a uniform 1,000 pound body weight as follows—Add to or subtract from the actual record of fat production 20 pounds of fat for each 100 pounds below or above 1,000 pounds body weight.

More interesting to the practical man are perhaps the writer's observations on cost of feed for cows of increased body weight compared with the value of the additional 20 pounds of fat so obtained. Evidence is produced which says that the greater production of large cows at best only slightly exceeds the cost of obtaining the additional product. It is concluded that the sires whose daughters are above the average for the breed in fat production without exceeding the average in body weight are especially desirable because their daughters are increasing the economy of fat production of the breed. A.D.B.S.

Milking Capacity and Constitution or Structure of the Hair in the East Frisian Milk Cow; The Connection between—(Zusammenhänge zwischen Milchergiebigkeit und Konstitution bezw. Bauart des Haares bei ostfriesischen Milchkühen).

E. SELAHATTIN. *Zeit. f. Züchtung, Reihe B.*, Vol. 19, pp. 100-27, 1930.

It is often thought that there is a connection between fineness of hair and high milk production. The author has investigated this problem, and states that during the course of his labours he has made about 300,000 hair cross-section and other measurements. No relation could be found between high milk production and the proportion of medulla in the hairs. The good milkers were found to have on the average larger thyroids than the poor milkers. They were also superior in constitution. Type of hair structure showed no correlation with these features. It was found that absence of medulla is much more frequent in pigmented hair (64 per cent.) than in white hair (8 per cent.). Considering pigmented hair alone no connection could be found between milking capacity and absence of medulla. It did appear that good milkers had little non-medullated white hair, but it is pointed out that this phenomenon may be accidental and peculiar to the animals studied. J.A.F.R.

"Nervous" Goats

J. L. LUSH. *J. Hered.*, Vol. 21, pp. 243-7, 1930.

A flock of goats on a Texas farm shows a remarkable hereditary condition resulting in a temporary loss of consciousness following sudden fright. If an unexpected loud noise or commotion occurs these goats become perfectly rigid, sometimes standing and sometimes falling to the ground. These paralytic fits last for only a short time, usually from 10 to 20 seconds, and the animals then regain the use of their muscles, the front part of the body recovering first. All the goats in the flock are rarely affected at the same time, and after one of these fits a goat cannot be thus frightened again until at least half-an-hour has elapsed.

Instances of similar nervous disorders in other animals are quoted, but although in the author's opinion the peculiar behaviour of these goats is almost unquestionably hereditary, owing to the lack of opportunity for breeding tests it was not possible to determine the manner of inheritance. J.A.F.R.

Newly Hatched Chicks; Inherited Inco-ordination of Muscles in

A. J. DURANT. *Abs. in Miss. Agr. Exp. Sta. Bull.*, 256, p. 102, 1927.

This disease appears to be a hereditary one and to be transmitted only through the males of the tainted family. Mated to healthy pullets of unrelated families, tainted male birds produce from fourteen to fifteen per cent. of chicks showing inco-ordination of muscles. Healthy pullets from this tainted family were mated to a healthy male. All the chicks from these matings were healthy. Further investigation is being carried out. A.D.B.S.

Pig Testing in Scotland; Experiences of

A. CALDER. *Pig Breeders' Annual*, 1930-1.

Eighteen months' experience of pig testing at the first Scottish Station to be established has demonstrated the value of the scheme. The test, which is actually carried out on four pigs from a litter, involves three main headings: prolificacy, which includes the number born and weaned and the weights at the time of weaning, economy of live weight gain and rate of maturity, and in the third place the suitability of the carcases for bacon purposes and the percentages dead to live weight and bacon to dead weight.

As an example of the value of testing it is shown how clearly late maturity in any strain is shown up. In this way breeders have been able to correct an undesirable tendency in their stock, a tendency which the author considers is fostered by the present show methods. It has been possible in a number of cases to show, by comparison with the general stock of the farm, that the feeding and management on the farm from which the pigs come are unsatisfactory. Prolificacy is another characteristic that probably is adversely affected by modern show-yard standards, and this fault too is clearly shown up in the test. The differences in economy of live weight gain are very large, the range extending from 3.6 lb. to 5 lb. of meal per pound increase of live weight. J.A.F.R.

"Porcupine" Pigeons—Studies on Inheritance in Pigeons—VIII

L. J. COLE and L. E. HAWKINS. *J. Hered.*, Vol. 21, pp. 51-60, 1930.

This remarkable abnormality is yet another case of a simple Mendelian condition affecting the skin and its appendages. The barbs and barbules of the feathers develop imperfectly, and later are largely worn off, leaving often little but the quill. Some of the birds showed in addition abnormalities in nervous co-ordination, but this was not universal. The condition is inherited as a simple Mendelian recessive. Porcupine pigeons were discovered in a white fan-tail stock and thirteen years later in homers. A reproduction is given of an illustration which undoubtedly represents a Porcupine pigeon, published in Aldrovandi's "Ornithologia" in 1600. J.A.F.R.

Quality and Palatability of Meat; Factors which influence the

A. E. TROWBRIDGE, A. G. HOGAN, M. T. FOSTER, W. S. RITCHIE, C. S. MADDOZ, J. A. CLINE, and H. C. MOFFETT. *Abs. in Miss. Agr. Exp. Sta. Bul.*, 256, pp. 55-62, 1927.

Only a few items out of many fall to be discussed in this abstract. With Range-bred high grade Hereford calves, brought up, fed and marketed under similar conditions, it was found that the net profit on the steers amounted to 3.28 dollars as compared with 6.21 dollars on the heifers. The steers consumed somewhat smaller quantities of concentrate and hay, however, while the heifers ate rather less silage. Whereas the steers gave 57.1 per cent. dead to live weight and were graded " Good ", the heifers gave a percentage of 58.2 per cent. and were graded as " High Good ".

There is a further report on the improvement of this herd by the use of pure-bred bulls. Calves sired by grade bulls were valued at two dollars per cwt. less than those sired by good pure-bred bulls.

A.D.B.S.

Records at the Zootechnical Institute, Göttingen; Fecundity, Fattening Capacity, etc.

J. SCHMIDT, H. VOGEL, and C. ZIMMERMANN. *Arbeiten der Deutschen Gesellschaft für Züchtungskunde*, Heft 17, 146 pp.

Germany is also joining the ranks of those countries which have Pig Testing Stations. As distinct from the common practice in other countries, the young pigs are not sent to the Testing Station till they are eleven weeks of age and measurements of food and weight are not commenced until their thirteenth week.

The trinity of results described in the British and American Testing Stations as fertility, economy and quality, are similarly described at Göttingen. In these tests no appreciable differences were found between pure-bred German pigs and an improved native breed. Each breed seemed to show a wide variability in efficiency and altogether the first results show the extremely useful purpose which pig testing serves.

A.D.B.S.

Sexual Maturity to Egg Production; The Relation of the Date of

H. L. KEMPSTER. 1926 *Miss. Agr. Exp. Sta. Res. Bul.*, 88, pp. 3-12. Abs. in *Miss. Agr. Exp. Sta. Bul.*, 256, pp. 18, 1927.

The studies forming the basis of this report have extended over seven years and include the trapnest records of 1,110 White Leghorns. Correlation studies were made between date of sexual maturity and winter egg production, and date that laying ceased. The author concludes that the optimum date of sexual maturity is about November 1st. Early layers make the best winter and annual records. There is a slight tendency for early layers to postpone the date on which they cease laying.

A.D.B.S.

Short Spine, a New Recessive Lethal in Cattle; with a Comparison of the Skeletal Deformities in Short-Spine and in Amputated Calves

O. L. MOHR and C. WRIEDT. *J. Genet.*, Vol. 22, pp. 279-97, 1930.

The authors continue their remarkable series of lethals in cattle. In the present case the most striking feature of the deformity is an

extreme shortening of the spinal column. The legs are of normal length and give the animal a most peculiar appearance. The neck is extremely short, so that the head looks almost as though it were fixed to the chest. The insertion of the tail is very high. The monsters have a curious elk-like appearance, and it is suggested that newspaper reports which appear from time to time of alleged cow-elk hybrids may in reality be due to the appearance of these short-spine calves. The calves are born at full term, and there are considerable difficulties in parturition. As a rule they are either still-born or die immediately after birth. In two cases the calves lived for one day and in one case for four days. It is shown that the condition depends upon a simple recessive factor. It was discovered in the Oplandske mountain breed of Norway, and does not appear as yet to have attained a wide distribution. The deformity produced by the present gene is contrasted with the condition " amputated " described in a previous paper, and it is shown that the effect of the two genes is strikingly " reciprocal ". There is a further discussion of the authors' suggestion in a previous paper that bulls should be tested by twenty matings to their daughters.

J.A.F.R.

Siamese Cat; Temperature Effects on the Colour of the

N. A. and V. N. Iljin. *J. Hered.*, Vol. 21, pp. 309-18, 1930.

It is known that in certain mammals exhibiting a certain type of pattern, for example, the Himalayan rabbit, the production of colour is conditioned to a greater or lesser extent by the external temperature. This dependance of colour formation on temperature is commonly known as the " Schultz reaction ". The Siamese cat falls into the same group. If the temperature is high the hair grows white; if the temperature is low it is pigmented. It was discovered that in addition to external temperature the physiological factors determining heat exchange exercised an effect, and that the threshold for pigment formation differed in different parts of the body. A sex difference was discovered, in that the threshold of irritation for the back of the male is higher than that of the female.

J.A.F.R.

PLANT PATHOLOGY.

Abstractor:

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Apple Scab; The Control of

J. S.E. Agr. College, Wye, No. 27, 1930. I. Bramley's Seedling and Newton Wonder. N. B. Bagenal, W. Goodwin, E. S. Salmon, and W. M. Ware.

On Bramley's Seedling, in 1924, the sprayed trees gave the following percentages of scab-free apples: Bordeaux mixture, three times (one plot), 53; twice, 37 and 27; Lime-sulphur, three times, 32 and 25; twice, no crop; Lime-sulphur plus arsenate of lead, three times (one plot), 52; twice (crop too small). The unsprayed control trees (one plot) gave only 4 per cent. of scab-free apples.

On the same variety in 1925, the sprayed trees gave the following percentages of scab-free apples: Bordeaux mixture, three times, 64 and 54; twice, 53 and 49; Lime-sulphur, three times, 61 and 51; twice,

60 and 39; Lime-sulphur plus arsenate of lead, three times, 57 and 49; twice, 52 and 48. The unsprayed control trees gave 38 per cent. and 30 per cent. of scab-free apples.

On Newton Wonder, in 1925, the sprayed trees gave the following percentages of scab-free apples: Bordeaux mixture, three times, 89 and 83; twice, 75 and 74; Lime-sulphur, three times, 88 and 84; twice, 89 and 87; Lime-sulphur plus arsenate of lead, three times, 87 and 83; twice, 87 and 69. The unsprayed control trees gave 78 and 68 per cent. of scab-free apples.

The addition of lead arsenate, except in one plot in 1924, did not improve the fungicidal action of lime-sulphur with either variety. In both seasons the lime-sulphur caused scorching injury, with occasional slight leaf-fall, on Newton Wonder. Scorching, and sometimes severe leaf-fall on this variety, followed the addition of lead arsenate to the lime-sulphur, but this did not occur with Bramley's Seedling whether the lead-arsenate was added or not. On both varieties, in 1925, lime-sulphur gave almost as good control of scab as did Bordeaux mixture.

II. Allington Pippin and Newton Wonder. W. Goodwin, E. S. Salmon, and W. M. Ware.

Trees of Allington Pippin sprayed three times with Bordeaux mixture gave 13 per cent. scab-infected apples; sprayed at the pink-bud stage with Bordeaux mixture, followed by two post-blossom applications of lime sulphur 1 in 60, gave 8 per cent. scab-infected apples, whilst the unsprayed controls gave 80 per cent., 80 per cent., and 70 per cent. scab-infected apples. Trees of Newton Wonder sprayed three times with Bordeaux mixture gave 26 per cent. scab; sprayed at the pink-bud stage with Bordeaux mixture followed by one post-blossom application of lime-sulphur 1 in 60, immediately after the fall of the petals, resulted in leaf-fall, while the same treatment caused no damage to Allington Pippin. Two post-blossom applications of lime-sulphur following a pre-blossom application of Bordeaux mixture gave no better "finish" to Allington Pippin that did three applications of Bordeaux mixture. No russeting of commercial importance was caused by Bordeaux mixture on either variety. T.W.

Apple Scab and Apple Mildew; The Incidence and Control of—at East Malling

M. H. Moore. Part I. Apple Scab. *J. Pom. and Hort. Sci.*, VIII. No. 3, pp. 229-47, 1930.

The results show that scab was checked on twigs, leaves, and fruits of Cox's Orange Pippin by Bordeaux mixture and by lime-sulphur, both containing lead arsenate, which slightly increased the beneficial effect on leaves. When applied (*a*) once before blossoming, there was little difference between the two fungicides; (*b*) twice, after blossoming, Bordeaux mixture proved superior to a weaker solution of lime-sulphur, (*c*) once before, and twice after, blossoming, when excellent control was given by both fungicides. Although rather more effective than the lime-sulphur, Bordeaux mixture is not recommended for use with this variety owing to the severe injury caused.

The scab pustule on young wood of Cox's is described as consisting of a series of "pads" of mycelium separated by corky tissue. After the bark splits, the fungus spores are liberated in succession from these pads over a considerable period.

Preliminary trials, for one year, with sulphur dusts were compared with a lime-sulphur spray. The dusts were slightly inferior, although the difference was small. There was no consistent evidence of injury following these treatments.

Both rootstock and manurial treatments have a marked influence on the degree of infection by scab. Different scion varieties react differently according to the rootstocks on which they are worked; while a possible differential effect of manuring on scab incidence on the fruit has been determined for one year only, but the conclusions are supported by records taken in 1928 of the percentages of clean and scabbed Worcester Pearmain apples from manured and unmanured plots.

Part II. Apple Mildew. M. H. MOORE, *ibid*, VIII, No. 4, pp. 283-304, 1930.

Spraying experiments on Cox's Orange Pippin and Stirling Castle showed that lime-sulphur applied three times, first in the pink-bud stage, at a strength of 1—30, second at petal fall at 1—100, and third at the same strength three weeks later, gave the best control of the disease. Gelatine was used as a "spreader" on Stirling Castle. Bordeaux mixture proved of little value in checking infection on Cox's, while sulphur sprays are not safe to use on Stirling Castle. Both colloidal sulphur and lime-sulphur (1—150) each with gelatine as a spreader, as post-blossom applications, reduced infection slightly, lime-sulphur at the strength used comparing very favourably with the same at 1—100 used with lead arsenate and no spreader.

Preliminary spraying and dusting experiments with Belle de Boskoop showed very good control of mildew by two post-blossom applications of soda-soap solutions (20—10—100) which, however, caused so much fruit drop that it is not safe to use at that strength on this variety. The other specifics tested showed little consistent promise, although the amount of infection during the two seasons was too slight to reveal significant differences in most cases. A proprietary white emulsion, lime-sulphur, and a proprietary sulphur spray all significantly reduced the crop in the one year, while there was significantly less fruit russeting on trees sprayed with the proprietary dusting sulphur and colloidal sulphur.

The results show that the rootstock upon which the scion variety is worked has an influence on the degree of mildew infection, stock No. 1 consistently inducing susceptibility. From the data available, manurial treatments had no significant effect on the degree of infection on Bramley's Seedling in 1928. T.W.

Arum Lily; Soft Rot of

W. F. BEWLEY and W. CORBETT. *Fifteenth Ann. Rept.*, Cheshunt Expt. Stat., pp. 52-8, 1929.

Good control of soft rot (*Bacillus aroideae*) of Arum lilies (*Zantedeshia aethiopica*) was obtained by shaking out the plant from the dry soil and removing all roots from the corm; washing and scraping away the decayed portions of the latter; steeping the plants in a 2 per cent. solution of commercial formalin for two hours; potting in soil sterilized by steam or boiling water; sterilizing soil and superstructure of houses with formalin and standing the pots on tiles previously sterilized by heat or formaldehyde, the last precaution being highly important as a means of preventing re-infection. T.W.

Cabbage; Control of Finger and Toe of

N. C. PRESTON, *Rept. Advisory Dept.*, Harper Adams Agr. Coll., V, pp. 5-9, 1930.

The original " watering in " method, by which about one-half pint of 1 in 1,500 or 1 in 2,000 solutions of mercuric chloride was applied to each hole immediately before planting, was tested against the easier " dipping " method. This latter method consists in adding dry soil to a quantity of the solution and dipping the plants in the mixture before planting. The results were, however, invariably in favour of the older method. T.W.

Cucumber and Tomato Mosaic Diseases; The Control of—in Glasshouses, by the use of Clean Seed

W. F. BEWLEY and W. CORBETT. *Ann. Appl. Biol.*, XVII, No. 2, pp. 260-5, 1930.

The authors submit evidence to show that mosaic disease of both cucumber and tomato is transmitted by the seed. Stocks of infected seed have been cleaned by early and careful rogueing of diseased plants. There is every reason to believe, say the authors, that in this country the incidence of this disease in glasshouses can be reduced to small proportions, if not entirely prevented, by the use of clean seed. T.W.

Oats; Leaf-Stripe or Yellow Leaf of

D. G. O'BRIEN and E. G. PRENTICE. *Scot. J. Agr.*, XIII, No. 3, pp. 272-84, 1930.

Leaf-Stripe of oats (*Helminthosporium avenae sativae*) is said to be by far the most destructive disease of this crop in Scotland, especially in the south-west, and necessitates a heavy rate of seeding 8 to 10 bushels per acre—in order to obtain reasonably good stands. On the average 25 per cent. of infection was found in the fields of the south-western counties. The old straw-producing varieties of oats, *e.g.*, Potato, Sandy, and Tam Finlay, appear to be much less susceptible than the new ones such as Marvellous, Victory, Ascot, Record, and Supreme. Early sown oats show a much higher incidence of primary leaf-stripe than those sown later, *e.g.*, 49 per cent. in March as compared with less than 5 per cent. late in May. Various commercial proprietary substances were tested for their efficiency in controlling the disease, the best results being obtained from the use of Ceresan dust at the rate of 2 ounces per bushel. T.W.

Oak Mildew and its Control in Forest Nurseries

R. C. WOODWARD, J. S. L. WALDIE, and H. M. STEVAN. *Forestry*, III, No. 1, pp. 38-56, 1929.

Oak mildew is stated to have been recorded first in this country in 1908 and now constitutes a serious menace to young plants in the nursery. It is most severe on seedlings and coppice and most commonly found on *Quercus pedunculata* and *Q. sessiliflora*, but occurs also on beech in this country and on sweet chestnut on the Continent. The disease is frequently more severe following defoliation by caterpillars or frost, and can be controlled by spraying with either colloidal sulphur—Ialine and Cosan—or flowers of sulphur made into a paste, at the rate of 2 to 4 lb. per 100 gallons. Calcium caseinate was a more

effective spreader than soft soap. Under favourable conditions one application may be sufficient, but usually three to five are necessary, the first one being made when the mildew first appears. These treatments secure that more than half of the plants are kept entirely free from mildew, height growth may be increased, and there is a great increase in the dry weight of the plants. Bud infection is decreased and the proportion of plants with good leaders is increased. T.W.

Onion; Autumn-Sowing Variety of Onion resistant to Frost and White Rot

E. HOLMES SMITH, *Gard. Chron.*, LXXXVI, No. 2240, pp. 429-30, 1929.

A satisfactory degree of resistance to white rot (*Sclerotium cepivorum*) has been shown by the White Welsh Onion variety in Lancashire and Cheshire. It is not commonly cultivated in England but might well be more extensively grown as a substitute for the popular White Lisbon, which is highly susceptible to white rot and also more liable to frost injury than the White Welsh onion. T.W.

Potatoes; Immature versus Mature Seed

T. WHITEHEAD. *J. Min. Agr.*, XXXVII, No. 5, August, pp. 452-5, 1930.

It is known that immature seed potatoes are frequently less infected with virus diseases and are, for this reason, preferable to mature seed in which there is a likelihood of heavier infection. The author describes a field trial to determine whether immaturity in itself, and apart from virus infection, confers any advantage over mature tubers for use as seed sets. Two crops of Great Scot and Kerr's Pink were selected as containing not more than 0.11 per cent. and 0.22 per cent. respectively of total virus diseases, on a farm where they spread very slowly. From these crops seed was raised on August 13, 1928, and again on October 12, 1928. The two lots of seed were planted in eight replications of 56 tubers, immature and mature seed occupying alternative drills. With the variety Great Scot the immature seed gave a mean yield of 191.5 lb. and the mature seed 191.6 lb. Similarly with Kerr's Pink the respective mean yields were 124.0 lb. and 118.5 lb. From these results it is concluded that, apart from the degree of freedom from virus diseases, there is no advantage to be gained by the use of immature seed for planting. T.W.

Potato Tuber; Watery Wound Rot of

G. H. PETHYBRIDGE and A. SMITH. *J. Min. Agr.*, XXXVII, No. 4, July, pp. 335-40, 1930.

The authors describe a type of rapid, watery, potato tuber rot about which serious complaints have been received from eastern counties but which also occurs in Shropshire. It is of a soft and wet type and differs from other well-known tuber-rots such as "pink-rot", blight and blackleg, in occurring only in tubers after being detached from the parent plant. The disease invariably starts from a wound or abrasion caused during lifting, whereas pink-rot and blackleg almost always start at the heel or stem end of the tubers. The skin over the diseased parts is dark and moist and a dark, almost black, boundary line is often seen between the healthy and diseased regions. The rot is caused by a soil fungus (*Pythium de Baryanum*) and the surest way of perpetuating the disease is to return the rotted tubers to the soil;

in the cases investigated the disease was most prevalent on those farms where it is not the practice to gather up and destroy diseased tubers after lifting. Since the rot-producing fungus enters the tuber through wounds it is desirable to prevent mechanical damage as far as possible during lifting and handling, and from this point of view the " spinner " is the worst type of implement to use in lifting. T.W.

Potato Stocks; A Study of the Degeneration of Certain

T. WHITEHEAD. *Ann. Appl. Biol.*, XVII, No. 3, pp. 452-86, 1930.

Trials were carried out in 1926 and 1927 with a view to studying the factors affecting the rate of degeneration, as measured by reduction in yield, of certain stocks of Kerr's Pink and Great Scot potatoes which had been maintained for varying periods from one to seven years without change of seed. With the exception of the seed grown since 1921, there was a progressive reduction in cropping power from the youngest to the oldest stocks and, again with the exception of the 1921 seed, this was paralleled by an increasing percentage infection with virus diseases. A statistical evaluation of the relationship between loss in yield and percentage virus infection showed it to be a linear correlation of a very high order, i.e., 0.83 ± 0.046 in the case of Kerr's Pink and 0.97 ± 0.008 in that of Great Scot. The rate of degeneration was equally marked whether ware, seed or chat, sets were planted. The percentage of " misses " also increased progressively from the youngest to the oldest stocks and this was ascribed to prolonged home-saving of seed and probably, though not certainly, mainly to virus infection.

There was no clear evidence in either variety of any marked reduction in the size of the tubers produced, which could be attributed to virus infection, but definite evidence was found that the proportion of large tubers in a crop is affected by the size of the set planted. In marked contrast to the degeneration in these stocks at the College Farm, near Bangor, no reduction in vigour was observed in either variety from the same stocks grown since 1922 at the Madryn Castle Farm School. Seasonal factors also, by influencing the rate of breeding of aphis vectors and the vigour of the potatoes, may considerably accelerate or retard the degeneration of a partially affected stock. The influence of variety on the rate of degeneration was found to be the resultant of three distinct forms of susceptibility, namely, liability of the haulms to contract infection, liability of the tubers to become infected from the diseased haulms, and the effect of infection on the yield.

T.W.

Scotch Potato Seed; Field Experiments on the Deterioration of

W. BROWN and V. H. BLACKMAN. *Ann. Appl. Biol.*, XVII, No. 1, pp. 1-27, 1930.

The authors have carried out experiments with three varieties of potato (Great Scot, Kerr's Pink, and King Edward) during the period 1922-4 in order to test the physiological theory of potato deterioration by determining whether the cropping power was influenced by early lifting or affected by shading the growing plants so as to protect them from overheating. Neither of these factors was found to affect the yield significantly so long as virus diseases were absent or very limited in amount. There was a significant falling off in yield in all the English-grown seed as compared with Scotch when considerable infection with

virus diseases had occurred in the former; this being less pronounced in seed which had been lifted at an early date. Evidence was obtained in one case that very immature seed is intrinsically inferior in cropping power to seed lifted at the normal time, i.e., apart from the effects of unequal distribution of virus diseases. A general correlation was observed between the amount of virus diseases in the various plots and the falling off in cropping vigour. No effect of a purely physiological nature arising from early lifting or from shading was indicated. Although not disproved, it could only be of minor account and quite subsidiary to the effects of virus disease. Rogueing experiments carried out in 1925-8 showed that in this way certain English-grown stocks, some of which were in their seventh year from Scotland, yielded as heavily as Scotch seed. To secure this maintenance of cropping power, however, necessitated such drastic removal of plants as to make the method uneconomic. T.W.

Tomato Leaf-Mould; The Relation of Atmospheric Temperature and Humidity to

T. SMALL. *Ann. Appl. Biol.*, XVII, No. 1, pp. 71-80, 1930.

The work has been carried out with a view to assisting growers to control this disease, caused by *Cladosporium fulvum*, by cultural methods. The author finds that 22°C is the optimum temperature for the various stages of the disease. At 10°C to 15°C severe infection occurs under humid conditions but the disease develops very slowly. Humidities exceeding 90 per cent. are very favourable to the disease. At 22°C infection is severe at 80 per cent. humidity but is rare at 70 per cent. At 18°C infection and subsequent development are considerably retarded at 80 per cent. humidity. Experiments indicate that seasonal variations in the severity of leaf-mould are related to temperature. Data are also given to show that humid conditions obtain in large glasshouses for several hours each night and that these conditions are largely responsible for the severity of leaf-mould. Wetting of the foliage by overhead watering does not appear to favour the disease, but excessive watering produces turgid, susceptible plants. A basis for controlling leaf-mould by cultural methods is suggested. T.W.

Wheat; "Dry-Pickling" or "Dusting" Seed—to prevent Bunt of

Co-operative Trials summarised by G. H. PETHYBRIDGE and W. C. MOORE. *J. Min. Agr.*, XXXVII, No. 5, August, pp. 429-39, 1930.

The results of trials carried out at the Ministry's Pathological Laboratory and at ten advisory centres in England and Wales, with a view to determining the relative values of the wet and dry treatments of grain to control bunt, are summarised. They show that the dry method of pickling seed wheat with copper carbonate compares at least very favourably with the older wet methods entailing the use of solutions of either copper sulphate or formalin. The dry treatment, however, costs rather more to apply and requires some form of machine in which the dust and grain can be thoroughly mixed. With such a machine the greater convenience of the dry dusting method would probably compensate for the slight additional cost. Examples of the cost of applying each method are given. T.W.

Wheat; The "Money" Side of Bunted

W. A. R. DILLON WESTON and F. L. ENGELDOW. *Essex County Farmers' Union Year Book*, 1930.

The authors state that the Official Seed Testing Station at Cambridge have recorded the following percentages of wheat samples in which bunt-balls were found:—1918, 6; 1919, 6; 1920, 8; 1921, 33; 1922, 16; 1923, 16; 1924, 14. These percentages—for a preventable disease—are regarded by the authors as very high and as showing no signs of diminishing. Many samples also may be contaminated with bunt spores without including whole bunt-balls, e.g., in one year 400 samples were examined and while only 18 per cent. of the samples contained whole bunt-balls, 64 per cent. were definitely contaminated with the disease. In order to test the effect of the presence of bunt-balls on the price quoted for samples of wheat, six samples of the same stock were artificially infected to different degrees with the disease and two millers were asked to quote market values—the presence of bunt not being disclosed to them. The prices quoted were as follows:—no bunt, 54/-; 20 bunt-balls per 1lb. wheat grains, 53/9; 30 per 1lb., 53/6; 40 per 1lb., 53/3; 50 per 1lb., 52/9; 60 per 1lb., 52/6. The last and most heavily infected sample corresponded to only one bunted plant in 450, or one-fifth of 1 per cent., in the field. The "money" side is further emphasised in a two-year history of a typical crop of wheat. In the first year only one plant in every 8,500 is bunted. Seed from this crop is sown; it contains one bunt-ball to every 1lb of seed. The resulting crop has one plant bunted in every 150 plants and this gives 60 bunt-balls to every pound of grain. When this grain is sold the price is cut by 1/6 per quarter as a direct result of the presence of the disease. Had the grain been sown instead of sold the crop would have had 25 per cent. to 30 per cent. of the plants infected and the grain would have been unsaleable and unusable. They conclude by showing that bunt can be effectively controlled by either formalin or copper carbonate.

T.W.

Leaflets by the Ministry of Agriculture and Fisheries, of interest to those engaged in controlling plant diseases, issued, revised, or re-written during the year 1930:—

Revised: No. 92, Bunt and Smut in Wheat.

Re-written: No. 365, Onion and Leek Smut.

Advisory Leaflet, No. 5, Potato Scab.

Advisory Leaflet, No. 9, Insecticides and Fungicides.

T.W.

SOILS AND MANURES.

Abstractor:

RICE WILLIAMS, M.Sc., University College, Bangor.

Bone Meal; The Results of Pot Experiments on the Effect of

E. TRUNINGER and F. KELLER. *Landw. Jahrb. Schweiz*, 1929, 43, 7, 931-45.

The results indicate that bone meals are only effective on acid soils low in phosphorus. No results are to be expected from neutral or alkaline soils well supplied with lime. The addition of gypsum did not

have any noticeable effect upon the action of the bone meal. The degree of fineness and the degree of degreasing have an important bearing upon the effectiveness of these fertilisers. R.W.

Lime and Magnesia; Repressive Effect of—upon Soil and Subsoil Potash

W. H. MACINTYRE, W. M. SHAW, and J. B. YOUNG. *J. Agr. Sci.*, 1930, 20, 4, 499-510.

Lysimeter experiments extending over periods of twelve and fifteen years show that economic additions of lime and magnesia, incorporated throughout the soil, have a depressive effect on the solubility of the soil potash. The effect is more marked in the subsoil than the surface soil. A slight increase in the solubility is observed in the lower layers when the lime or magnesia is applied to the surface layers. R.W.

Moisture; When the Soil Mulch Conserves

C. F. SHAW. *J. Amer. Soc. Agron.*, 1929, 21, 12, 1165-71.

Experiments were carried out at the Californian Experiment Station with soils packed in iron tubes. It is concluded as the result of these experiments that when the water table is within easy capillary reach of the surface the soil mulch reduces the rate of evaporation of moisture from the soil, but in the case of any water table, perched or permanent lying at a depth such that the capillary rise cannot lift the water to the surface, there can be no losses of soil moisture that the mulch can materially reduce. It is pointed out that, under such conditions, any effort to conserve moisture may be unnecessary since the root zone will have abundant moisture. R.W.

Nitrate Changes in a Fertile Soil as Influenced by Sodium Nitrate and Ammonium Sulphate

N. PORGES. *Soil Sci.*, 1929, 29, 1, 449-55.

The nitrogen in the crop and leachings was found to be less than the total nitrogen originally available. From 25 per cent. to 30.5 per cent. was retained by the soil. The addition of sodium nitrate and ammonium sulphate mineralises part of the soil nitrogen. The plant was found to have a depressive effect on the accummulation of nitrates in the soil. R.W.

Nitrate Production and the Retention of Moisture in Soils; Effect of Cultivation on

W. H. METZER. *Arkansas Sta. Bull.*, 1929, 246, 26-7.

The results of four years' experimental work show that the different methods of cultivation whereby the soil is stirred has practically no effect on the production of nitrates in soils. Emphasis is laid on the necessity for the prevention of weed growth in order to conserve nitrates for plant consumption. It is also pointed out that weed growth wastes moisture supply. R.W.

Nitrate v. Sulphate in Fertilising Potatoes

New Hampshire Sta. Bull., 1930, 250, 22-5.

The results of two years' tests on the relative effectiveness of nitrate and sulphate fertilisers as sources of inorganic nitrogen for potatoes indicate, from the standpoint of total yields and size of tubers, that sulphate alone is not quite as desirable as nitrate alone and that neither alone is quite as good as a mixture of the two. R.W.

Nitrogenous Fertilisers on Pasture Land; Experiments with

H. Osvald. *Svenska Mosskulturför Tidskr.*, 1930, 44, 2, 67-84.

The work described was carried out on a meadow overlying deep "white moss" or sphagnum peat. The conclusion drawn from the trials was that spring applications of nitrogen give much better results than late or divided applications; that ammonium sulphate was the most effective form in which to apply the nitrogen and that nitrogen treatment increased meadow fescue and red fescue. In addition to the nitrogenous manuring, the plots received annual dressings of superphosphate or basic slag and potash salts. R.W.

Peat; The Influence of—on the Utilisation of Phosphoric Acid from Phosphates

Z. V. Logvinora. *Udobrenie i Urozhaĭ*, 1929, 4, 211-6.

Raw phosphates with peat had a more prolonged effect on the yield of clover than had phosphates alone. Meadow peat, less highly unsaturated than peat moss, did not give as good results when mixed with phosphates. The higher the unsaturation of the peat the greater was the quantity of soluble phosphate obtained. R.W.

Peat; The Use of—in the Greenhouse

A. Laurie. *Michigan Sta. Spec. Bull.*, 1930, 191, 28.

When used alone, as a substitute for the usual compost of soil and manure, the peat was not satisfactory, but when mixed with as little as 1/20 of its volume of manure the peat was in some cases superior to the ordinary compost. Used as a mulch about one inch deep over the surface of the soil in benches, or with soils for potting in the proportion of one part to five parts a marked increase in growth and larger and better flowers were obtained in the case of most greenhouse crops. It serves as a suitable substitute for stable manure when mixed with that material in the proportion of 20 : 1 by volume. R.W.

Peat Soil as a Means of Soil Improvement on Humus-poor Sand Soils

E. Nyström. *Svenska Mosskulturför Tidskr.*, 1930, 44, 2, 85-117.

Treatment of a poor sand soil with low-moor peat gave large increases in yield during a summer of normal rainfall. Under these conditions a noticeable increase in the soil moisture was obtained. In a dry season, however, the addition of the peat gave only small increases in yield. This is attributed to the supply of water being too small in relation to that needed for producing marked effects. R.W.

Raw Sludge; The Value of—as a Fertiliser

J. F. Muller. *Soil Sci.*, 1929, 29, 6, 423-32.

The analysis of dried samples of fresh sludge showed the presence of appreciable plant food. This dried sludge, when applied to grass grown on sand, gave a good stand and prevented the grass from dying off. An important increase in the water-holding capacity of the sand was also shown. It was found that the addition of nitrogen to the extent of bringing the carbon-nitrogen ratio down below 8, together with phosphate and a small amount of potash appeared to be needed. R.W.

Soil Liming Materials; Comparison of

Indiana Sta. Rept., 1929, p. 13.

10 mesh and 50 mesh ground limestone and marl produced as large increases in crops as hydrated lime and at a lower cost per acre. Further, 50 mesh limestone was found no more effective than the 10 mesh. It is suggested that 4 mesh limestone screenings, though less effective than the finer materials, may be satisfactory if used in larger amounts.

R.W.

Soil Organic Matter; The Carbon-Nitrogen Ratio of

W. McLean. *J. Agr. Sci.*, 1929, 20, 3, 348-54.

Soils from limited areas were found to give approximately constant C/N ratios. These ratios varied from place to place according to climate, etc. The ratios for arable soils did not differ appreciably from those of grassland but the percentages of C and N were somewhat higher in grassland samples than in arable samples. It is suggested that the organic carbon or nitrogen might be used as an index to fertility in the examination of the crop-bearing soils in the same area.

R.W.

Soils and Fertilisers

Sir E. J. Russell. *Agr. Research*, 1929.

Among the subjects discussed are the following: (1) Soil surveys, (2) Reclamation of sand and heath land, (3) Reclamation of peats or moors, (4) Losses of soil and soil erosion, (5) Comparison of farmyard manure with artificial fertilisers, (6) Effect of weather on the action of fertilisers, (7) Artificial farmyard manures. R.W.

Subsoil an Important Factor in the Growth of Apple Trees in the Ozarks

A. T. Sweet. U.S. Dept., *Agr. Circ.*, 1929, 95.

Within the limits of the region studied, a definite relation between conditions obtaining in the subsoil and the growth and health of apple trees was demonstrated. It was found that with open subsoils the trees were larger, produced better, and lived longer than did trees grown on tight subsoils. Twenty-year-old trees were found to possess a root structure penetrating and feeding on about twice the volume of soil when grown over open subsoils as compared with the tight subsoil. Care in cultivation, control of disease, etc., may seem to overcome the handicap of tight subsoil when the orchard is young, but this is not so when the trees become older and their demands greater. R.W.

Urea; Decomposition in Soils

T. Gibson. *J. Agr. Sci.*, 1930, 20, 4, 549-58.

In a large number of soil samples examined, the decomposition of urea was general, and very rapid in most cases. Permanent pastures produced more rapid decomposition than cultivated land. Samples of forest soils were in general more active than those from cultivated ground. Although urea is not absorbed by soil, its rapid conversion to ammonia will generally prevent losses by leaching. R.W.

AGRICULTURAL BOOKS, 1930.

The following list, prepared by the staff of the National Library of Wales, is a selection of the more important books on the science and practice of Agriculture published during the year 1930, together with a few omitted from the list for 1929. The list supplements *The Hand List of Books on Agriculture* issued by the National Library, *third edition*, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

BARDWELL, F. A. The herb-garden . . . *2nd ed.* London : A. & C. Black, 1930. pp. xii, 174. col. front., col. pls. ... ... 7s. 6d.

BARKER, A. F. The sheep and wool of South Africa, Rhodesia, and Kenya Colony. [*No imprint*, 1930]. pp. 58. ill., diags., maps.

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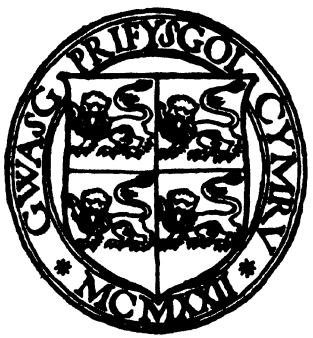

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FURTHER STUDY OF SOME FACTORS OF EFFICIENCY IN MILK PRODUCTION.

By J. Pryse Howell, M.Sc.,

University College, Aberystwyth.

Studies in the cost of milk production on some farms in Wales were begun by the Agricultural Economics Department at Aberystwyth in 1925 and were continued over a period of five years. The results of the investigation for the first three years have already been published,[1] and this article deals with the last two years of the study. During this period returns have been obtained for twenty-six cases, each giving the average of one herd for one year. In the collection of the data, the same general plan has been followed as in the previous study. The production of milk was only one of the enterprises on the farms where the investigations were conducted. On a few of them it was practically the sole enterprise, and crops were grown simply for the maintenance of the herd. On other farms milk production was combined with other livestock enterprises and the growing of some crops for sale. None of these other enterprises were considered in any way. The dairy cow is the unit basis of study, and no attempt is made to take other livestock or any other farm enterprise into consideration. Credit is given for the value of the calf as soon as the cow's milk is fit for human consumption, and all heifers are charged into the herd at their estimated value as soon as they freshen.

There are variations in the method of disposal of milk. Some farms produce milk mainly for the liquid milk trade, others combine this method with the sale of butter, cream and some cheese, and a few herds are used for stock raising and incidentally for butter-making.

Cost items.

No records of " costs " of producing crops were obtained from the farms concerned. The estimated "costs of production" value of *home grown foods* was determined after consideration of the cost of the commodities on other farms and in some cases after discussion of cost of the commodities with the owners of individual herds. The cost per unit for home grown foods may

[1] Pryse Howell. Some Factors of Efficiency in Milk Production. This *Journal*, Vol. VII, 1931.

therefore be described as " conventional costs ". Some variation existed in the costs from farm to farm, but the average unit costs were as follows :—

	Per ton. £	s.	d.
Hay	2	17	0
Straw (mainly oat)	2	5	0
Roots	0	17	10
Other green foods	1	8	6
Home-grown corn	8	2	4

All *purchased* foods were charged at their actual cost price, plus carriage to the farm where necessary. The average prices per ton for the general classes specified were, purchased cakes, £10 7*s*. 11*d*., and meals £10 5*s*. 5*d*. To ascertain the cost of *pasturage* was one of the most difficult problems, because the cows are not grazed alone on pastures or aftermath. The cost as given consists of a complex calculation with these items; rent, rates, manures, labour, etc., on pastures, days of cow pasturage and pasturage of other stock. *Labour* includes all production labour costs—feeding, milking and general dairy work, whether done by the farmer or his family or by hired persons. The rate of wages allowed for unpaid family labour was the same as that paid for hired workers of a similar class. Labour employed in the delivering of milk has been treated separately and has been included in delivery costs. The *cost of keep of bull*, attendance and feed, is about equal to the cost of feed per cow in herd. Depreciation on bulls is included with depreciation on the general herd, but can be separately ascertained. Credits for service fees were deducted from gross costs, but on most farms little revenue was derived from this source. Some farmers did not keep bulls, but paid service fees at from 3*s*. 6*d*. to 6*s*. per head of cows. *Depreciation on the herd* is arrived at by taking the valuation of the herd at the beginning of the year plus the price of cows and bulls bought and the value of heifers transferred into the herds. From this is deducted the sales of cows and bulls plus the valuation of the herd at the end of the year. The difference of these two values being depreciation. *Depreciation on equipment* was allowed at the rate of 10 per cent. per annum on milking machines, separators, coolers, churns, and other equipment used in milk production. The item *miscellaneous costs* includes veterinary expenses, milk recording fees, expenditure on fuel for food preparing machinery, and for washing utensils, and a considerable variety of small expenses not provided for elsewhere. The item common to nearly all these miscellaneous charges is expenditure on veterinary services or on various medicines.

Delivery costs have been separated from those of production. In the assessment of costs, the total cost of upkeep of horses, including all charges, was assessed by the farmer, and the figure given was accepted, and similarly with motors. But only a proportion of the costs of keep of horses or running motors and depreciation of horses or vehicles according to the proportion of the time worked have been charged to milk. Depreciation on horse equipment has been allowed at 10 per cent. and motors at 20 per cent. In the case of churns, cans, measures, etc., full depreciation has been allowed. Manual labour cost was that of actual time spent on milk delivery.

Credits.

Besides service fees received there are several credit items to be allowed. The raising of *calves* was not considered as a part of the milk cost. All calves which were not sold were valued by the farmer as soon as the cow's milk was fit for human consumption and credited to the herd. No deductions have been made in respect of *manurial residues* in home grown foods other than corn and meal. Manurial residues have been allowed for these and purchased food at one-half of the theoretical standards (Hall and Voelckers Tables), because it is estimated that this figure more nearly represents residual values on these farms. All *milk* produced by the herd during the year was credited to the receipts. The value of milk used in the household and that fed to pigs and calves was assessed at cost of production. Milk used for butter and cheese-making was valued according to the price realised for the product. An allowance was made for separated milk at the rate of 2*d.* per gallon, butter milk at ½*d.* per gallon, and whey at 1*d.* per gallon.

General conditions.

The average size of the herds was about nineteen cows. Of the total, 19 per cent. of the herds consisted of less than ten cows, 35 per cent. of ten and under twenty, 35 per cent. of twenty and under thirty, and 11 per cent. of over thirty cows. The largest herd had forty-seven and the smallest herd had six cows. The average costs over all the herds during the two years are given in Table I. The average figures are weighted by size of herds.

Allowing for the value of the credits, the net expenses per cow were £23 and 8.89*d.* per gallon. Of the gross costs the value of the food including grazing was £16 14*s.* 9*d.* per cow, the average cost of manual labour was £5 13*s.* 4*d.*, and other expenditure

which can be regarded as overhead charges amounted to £3 5s. 8d. per cow. Expressed in round numbers, these three classes of expense show the following percentages :—

	Present study.	*Previous study.*
Food	65 ...	63
Labour	22 ...	23
Overhead charges ...	13 ...	14

The variations in yield of milk are given " per cow in herd " which represents the total yield of milk divided by the number of cows reduced to cows on the farm for a whole year; and " per cow in milk ", which represents the total yield divided by the number of cows reduced to " one cow in milk for one year ", the reduction in this case being the allowance for the period which the cows spend in dry condition.

	Per Cow in herd. gallons.	*Per Cow in milk.* gallons.
Average milk yield (two years) ...	621	753
Herd with lowest yield (two years) ...	412	519
Herd with highest yield (two years) ...	866	993

TABLE I.

Average cost of producing milk (two years' results). (Twenty-six cases).

	Total.	*Average.*
Number of cows in herd	505	19.4
Number of cows in milk	416	16.0
Number of cows dry	89	3.4
Total milk yield	313,568 gals.	
Average per cow in herd	621	
Average per cow in milk	753	

	Cost per cow.	*Cost per gallon.*	*Per cent. to total.*
	£ s. d.	Pence.	Per cent.
Home grown foods	6 5 0	2.40	24.33
Purchased foods	6 14 5	2.60	26.16
Pasturage	3 15 4	1.46	14.67
Labour	5 13 4	2.19	22.07
Depreciation on cows	1 6 5	0.51	5.14
Depreciation on equipment ...	0 7 0	0.14	1.36
Keep of bull or cost of service ...	0 14 8	0.28	2.85
Miscellaneous	0 17 7	0.34	3.42
Gross cost	25 13 9	9.92	100.00
Credits	2 13 8	1.08	10.45
Net cost	23 0 1	8.89	89.55
Delivery cost	2 13 0	1.02	
Total cost	25 13 1	9.91	
Total receipts	39 1 11	15.12	
Balance	13 8 10	5.21	

The highest and lowest costs per cow show very wide variations (Table II). The highest cost is found in a small herd which is kept for the purpose of supplying milk to a neighbouring town. The high cost is due to heavy purchases of concentrates and that the farmer has been very unfortunate with his herd. Apart from losses through death, there have been udder and other ailments amongst the herd which have resulted in very heavy depreciation. The herd with the lowest cost is situated in a fairly open pasturage area with a relatively short winter feeding period. The cows are all home-bred and there was some appreciation of value in the herd.

When costs are measured against the highest and lowest yields, two herds are found in an open grazing area. The highest yield is found on a pasture farm where the cows have been carefully selected for milking. Milk records are kept and the feeding of the cows is studied. The lowest yield is found in a large herd where the management both as regards the selection and feeding of the cows is not very efficient.

Cost of food.

The cost of food at about 65 per cent. of the total gross cost has the greatest influence on the possibilities of economic production. With price and quality of foods the dominant considerations, there remains the problem of combining them into a balanced ration. Probably the gravest mistakes of the business exist in this single problem. While progressive farmers have discarded the wasteful and extravagant practice of giving the same amount of food to all cows, it is felt that there is still much room for instruction in the keeping of food records and in the most economical rationing for milk production. The quantities and kind of home grown foods available determine to a great extent the system of feeding, and if farmers were as familiar with the chemical composition of the foods produced on the farm as they are with those of purchased foods, a considerable saving would often be made in the cost of food for the dairy herd. The quality of home grown foods varies greatly and depends on the character of the soil, weather conditions and methods of handling. These variations from the average analysis must be taken into consideration when combining foods into rations. Hay, cut in the earlier stages is more nutritious than when cut at or near maturity, and much of the hay fed does not fulfil expectations in results because of deterioration due to late cutting. Again, its feeding value may suffer owing to exposure to sun or moisture. Oats and barley may be of low quality because the weather conditions were unfavourable for the ripening of the crops. In respect of summer feeding,

TABLE II.
Comparison of costs (mean of two years' results).

	Herds with highest and lowest cost per cow.						*Herds with highest and lowest yields.*					
	Highest cost.			*Lowest cost.*			*Highest yield.*			*Lowest yield.*		
No. of cows in herd	10.66			11.88			18.28			46.88		
No. of cows in milk	8.44			9.42			15.90			37.23		
No. of cows dry ...	2.22			2.41			2.38			9.58		
Total milk yield ...	7,400 gals.			5,593 gals.			15,781 gals.			19,322 gals.		
Yield per cow in herd	694 gals.			478 gals.			866 gals.			412 gals.		
	Cost per cow.	*Cost per gallon.*	*Per cent. to total.*	*Cost per cow.*	*Cost per gallon.*	*Per cent. to total.*	*Cost per cow*	*Cost per gallon.*	*Per cent. to total.*	*Cost per cow.*	*Cost per gallon.*	*Per cent. to total.*
	£ s. d.	Pence.	%	£ s. d.	Pence.	%	£ s. d.	Pence.	%	£ s. d.	Pence.	%
Home grown foods ...	5 7 7	1.86	13.4	5 2 2	2.59	34.6	6 1 6	1.68	22.2	7 5 8	4.28	28.7
Purchased foods ...	10 1 7	3.48	25.0	1 8 0	0.71	9.5	9 13 4	2.69	35.5	4 3 5	2.48	16.4
Pasturage ...	4 7 4	1.51	10.9	3 11 2	1.81	24.1	2 15 6	0.77	10.1	4 15 4	2.77	18.8
Labour ...	5 15 3	1.99	14.4	3 18 1	1.98	26.4	4 15 11	1.84	17.5	7 11 7	4.41	29.9
Depreciation on cows	7 11 0	2.62	18.7	—	—	—	2 6 7	0.68	8.4	0 10 1	0.29	1.9
Depreciation on equipment ...	0 2 8	0.04	0.3	0 3 8	0.09	1.3	0 0 4	0.01	0.1	0 5 0	0.14	0.9
Keep of bull or cost of service ...	2 4 2	0.76	5.4	0 8 10	0.23	3.0	1 3 0	0.32	4.2	0 7 11	0.23	1.4
Miscellaneous ...	4 17 11	1.69	12.1	0 3 5	0.08	1.1	0 11 0	0.15	2.0	0 10 8	0.31	2.0
Gross cost ...	40 7 6	13.95	100.0	14 15 5	7.49	100.0	27 7 8	7.59	100.0	25 9 8	14.81	100.0
Credits ...	2 16 1	0.96	6.9	2 16 7	1.44	19.2	3 14 8	1.04	13.6	1 18 3	1.12	7.4
Net cost ...	37 11 5	12.99	93.1	11 18 10	6.05	80.8	23 13 0	6.55	86.4	23 11 5	13.69	92.6

there is ample evidence that the quantity and quality of the pasture on many dairy farms could be greatly improved and the cost of milk thereby lessened by greater and wiser expenditure on manures. Dry cows do not require as much food as those in milk, but it is important that the cows that are dry should be fed well enough to ensure them being in good condition at time of calving. Cows in milk require food for body maintenance and to provide the material necessary for the production of milk. The kind and quantity will depend on the live weight of the cow and the quantity and quality of the milk. Individual cows vary in their inherent capacity to produce milk, and the dairy farmer who is going to make a success of his business must feed according to the individual needs of each of his cows. These are all factors which have to be considered in determining the amount and kind of food to be fed to the dairy herd.

TABLE III.

Home grown and purchased foods fed per cow and per 100 gallons.

Number of herds.	12		14		26	
Food.	*Group 1. Under 600 gals.*		*Group 2. Over 600 gals.*		*All groups.*	
	Per cow.	*Per 100 gals.*	*Per cow.*	*Per 100 gals.*	*Per cow.*	*Per 100 gals.*
	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
Hay ...	25.82	5.38	27.90	3.95	27.11	4.37
Straw ...	7.06	1.47	1.77	0.25	3.77	0.61
Roots ...	20.35	4.25	12.94	1.83	15.74	2.53
Other green foods	4.62	0.96	3.38	0.48	3.84	0.62
Total bulk food	57.86	12.06	45.99	6.51	50.47	8.13
Home grown corn	3.25	0.67	1.90	0.27	2.41	0.39
Purchased cakes	3.89	0.81	8.31	1.18	6.64	1.07
Purchased meals	4.85	1.02	7.28	1.03	6.36	1.02
Total purchased foods ...	8.74	1.83	15.59	2.21	13.00	2.09
Total concentrates home grown and purchased ...	11.99	2.50	17.49	2.48	15.41	2.48

The average quantity of hay fed is slightly over 27 cwt. per cow. Less hay per cow is consumed by the group of herds producing under 600 gallons than on those producing over this quantity. When, however, roots and other green foods are considered, the figures show that considerably more of this class of

food is consumed by the lower than by the higher yielding herds. The quantity consumed per cow being about 25 cwt. on Group I as against 16⅓ cwt. on Group II. The average for all the herds

TABLE IV.

Gross cost of home grown and purchased food per cow and per 100 gallons.

Number of herds.	12		14		26	
Food.	*Group 1. Under 600 gals.*		*Group 2. Over 600 gals.*		*All groups.*	
	Per cow.	*Per 100 gals.*	*Per cow.*	*Per 100 gals.*	*Per cow.*	*Per 100 gals.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Hay ...	3 18 7	0 15 4	3 19 6	0 11 3	3 17 8	0 12 6
Straw ...	0 15 7	0 3 3	0 4 2	0 0 7	0 8 6	0 1 4
Roots ...	0 17 10	0 3 8	0 11 10	0 1 8	0 14 1	0 2 3
Other green foods	0 7 6	0 1 7	0 4 3	0 0 7	0 5 6	0 0 11
Total bulk food	5 14 6	1 3 10	4 19 9	0 14 1	5 5 4	0 17 0
Home grown corn	1 6 5	0 5 6	0 15 5	0 2 2	0 19 8	0 3 2
Purchased cakes	1 12 9	0 6 10	4 11 0	0 12 11	3 9 1	0 11 1
Purchased meals	2 14 8	0 11 5	3 11 11	0 10 2	3 5 4	0 10 7
Total purchased foods ...	4 7 5	0 18 3	8 2 11	1 3 1	6 14 5	1 1 8
Total concentrates home grown and purchased ...	5 13 11	1 3 9	8 18 4	1 5 3	7 14 1	1 4 10

TABLE V.

Total gross cost of home grown foods, purchased foods, and grazing per cow and per 100 gallons.

Number of herds.	12		14		26	
Food.	*Group 1. Under 600 gallons.*		*Group 2. Over 600 gallons.*		*All groups.*	
	Per cow.	*Per 100 gals.*	*Per cow.*	*Per 100 gals.*	*Per cow.*	*Per 100 gals.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Home grown ...	7 0 11	1 9 4	5 15 2	0 16 3	6 5 0	1 0 2
Purchased ...	4 7 5	0 18 3	8 2 11	1 3 1	6 14 5	1 1 8
Grazing ...	3 10 0	0 14 7	3 18 6	0 11 2	3 15 4	0 12 2
All foods and grazing ...	15 8 4	3 2 2	17 16 7	2 10 6	16 14 9	2 14 0

is 19½ cwt. per cow. As regards straw, the amount consumed per cow is 7 cwt. for Group I and 1¾ cwt. for Group II, with an average of 3.77 cwt. for all the herds. The concentrates (home grown and purchased) fed per cow amount to about 12 cwt. for the herds producing under 600 gallons and 17½ cwt. for the herds producing over 600 gallons, the average being about 15½ cwt. per cow.

The quantity of food fed per 100 gallons of milk produced for each Group is as follows :—

	Group 1. *Per* 100 *gallons.*	*Group* 2. *Per* 100 *gallons.*	*All groups. Per* 100 *gallons.*
	cwt.	cwt.	cwt.
Total bulk foods	12.06	6.51	8.13
Total concentrates (home grown and purchased)	2.50	2.48	2.48

While about the same amounts of concentrates are fed per 100 gallons of milk produced on both groups, the herds producing under 600 gallons consume about twice as much bulk foods.

The gross cost of home-grown and purchased foods per cow and per 100 gallons is given in Table IV.

The average gross cost of bulk foods is £5 5*s.* 4*d.* per cow and 17s. 0d. per 100 gallons, and the average gross cost of concentrates (home-grown and purchased) is £7 14*s.* 1*d.* per cow and £1 4*s.* 10*d.* per 100 gallons. The gross cost of all foods is £12 19s. 5d. per cow and £2 1*s.* 10*d.* per 100 gallons. When the value of grazing is added, the average gross cost of the foods including grazing is £16 14*s.* 9*d.* and £2 14*s.* 0*d.* per 100 gallons (Table V). It may be noted here that these figures are very similar to those obtained for the previous study, where the results showed a gross cost of foods including pasturage of £16 16*s.* 5*d.* per cow and £2 16*s.* 0*d.* per 100 gallons. Further, the results indicate the same general tendencies in that the gross cost of food (including grazing) per cow rises from the lower to the higher yielding herds and that there is a decrease in the cost of food per 100 gallons of milk produced. A summary of the results is as follows :—

	Group 1.	*Group* 2.	*All groups.*
	£ s. d.	£ s. d.	£ s. d.
All foods including grazing, per cow	15 8 4	17 16 7	16 14 9
All foods including grazing, per 100 gallons	3 2 2	2 10 6	2 14 0

From these gross costs, deductions have been made for the value of manurial residues and the results are summarised below.

	Group 1.	*Group* 2.	*All groups.*
	£ s. d.	£ s. d.	£ s. d.
All foods including grazing, per cow	14 11 1	17 2 7	16 2 6
All foods including grazing, per 100 gallons	3 0 8	2 8 5	2 12 0
Net cost of production, per cow ...	20 7 7	24 11 11	23 0 1
Net cost of production, per 100 gallons	4 4 11	3 9 7	3 18 11
Average yield per cow in herd (gallons)	480	706	621
Average yield per cow in milk (gallons)	599	842	758

These figures emphasise the importance of the yield of milk as one of the chief factors in the determination of costs. While it does not always follow that high yields of individual herds will be produced at low costs or low yields at high costs, the general tendency is, however, for high yields to be accompanied by low costs per gallon.

Purchase or Production of Food.

It has already been stated that for home grown foods, the cost per unit may be described as "-conventional costs ". For this reason, anything which may be stated on the comparative advantage of growing or buying foods is subject to any qualification which might be necessary because of the method adopted in assessing the value of home grown foods.

In Group I the home grown foods account for nearly 62 per cent. of the total cost of food, and in Group II, 41 per cent. It does not necessarily follow that high cost of milk occurs with high proportion of purchased foods or *vice versa*. The economy of home grown foods will depend upon the management of the crops and their costs, and of purchased foods on the nature of the foods bought, their food value in relation to price at time of purchase. The economy of foods, whether home grown or purchased, cannot be determined by cost alone, but is determined by cost in relation to feeding value. There is also an important consideration with relation to home grown foods, that they are inclined to be fed with less regard to economy in quantity than those which are purchased.

The summary of the cost of home grown foods and purchased foods per gallon of milk produced is as follows ;—

Gross cost of food per gallon of milk.

	Home grown.	*Purchased.*	*Total.*
	Pence.	Pence.	Pence.
Group 1	3.52	2.19	5.71
Group 2	1.95	2.77	4.72
All groups	2.42	2.60	5.02

These are gross costs, and when reduced by the credit for value of manurial residues, the result is approximately as follows :—

Net cost of food per gallon of milk.

	Yield per cow in herd.	*Home grown.*	*Purchased.*	*Total.*
	Gallons.	Pence.	Pence.	Pence.
Group 1 ...	480	3.49	2.04	5.53
Group 2 ...	706	1.93	2.54	4.47
All groups ...	621	2.40	2.38	4.78

With home grown foods, manurial residues were only allowed for corn and meal, and the bulk of the value of manurial residues is due to purchased foods. The results confirm the findings of the previous investigation in that a high proportion of costs due to home grown foods is accompanied by high cost of food per gallon. The difference in yield of milk between these two groups is over 200 gallons per cow.

From the figures that follow, it will be seen that the herds with the lower yields consume much larger quantities of food in

Quantities of bulk and concentrated feed, and cost of pasturage per gallon of milk.

Group.	*Hay.*	*Straw.*	*Roots and green foods.*	*Total bulk foods.*	*Concentrates.*	*Pasturage.*
	lb.	lb.	lb.	lb.	lb.	Pence.
Group 1	6.02	1.65	5.83	13.50	2.05	1.75
Group 2	4.42	0.28	2.59	7.29	2.78	1.34
All groups	4.89	0.68	3.53	9.10	2.78	1.46

relation to their production than do the higher yielding herds. This may be partly due to low quality of foods and lack of

balance in the ration, but more to the fact that the higher producing cows are more efficient in converting food into milk than the low producers. The natural yield capacities of the cows and methods of feeding combine to produce the results shown.

Production Labour.

The production man-labour hours for these herds varied from 110 to 291 with a general average of 196 hours per cow per annum. In the previous study the average labour requirement per cow was 211 hours. These figures agree fairly closely with the results shown for similar studies in England[2] in that they show a manual labour requirement of about 200 hours per cow per annum.

In Table VI the number of hours per cow and per 100 gallons of milk produced has been analysed according to the size of the herd.

TABLE VI.

Size of herd and labour hours per cow and per 100 gallons.

Group.	*No. of herds.*	*Average No. of cows in herd.*	*No. of hours per cow.*	*No. of hours per 100 gals. of milk.*	*Yield per cow in herd.*	*Yield per cow in milk.*
Size of herd	No.	No.	No.	No.	gals.	gals.
Under 18	13	11.2	169	30	557	680
Over 18	13	27.7	207	32	646	782
Average		19.4	196	32	621	758

It might have been expected that as the herds increased in size, the labour per cow would diminish, but the reverse is true as far as these particular herds are concerned. There are many factors which would probably account for the higher labour requirements per cow on the larger herds. The proportion of the cows in milk to the total number in herd is slightly more and the percentage of winter calving is higher—57 per cent. as against 52 per cent. for the smaller herds. Again, there has to be considered the fact that, included in the larger herds are a number of cases producing Grade A milk and that eleven out of the thirteen herds are producing milk solely for the liquid milk trade. Another important consideration as affecting the labour requirements of

[2] Liversage. Economics of Production of Grade A (Tuberculin Tested) Milk. Oxford Clarendon Press, 1926, p. 46.

these herds, is the practice of the summer feeding of the cows on the pastures.

Of the smaller herds, there are only five that produce milk entirely for the liquid milk trade, others combine this method with either the sale of butter, cream or cheese, and there are two cases where the milk is mainly utilised for the production of butter.

For the farms which have an average herd of about eleven cows, the labour requirement is thirty-eight hours less per cow than for those herds of about twenty-eight cows. When the labour is considered in relation to the yield of milk produced, the two groups are very similar, the number of hours per 100 gallons of milk being thirty for the herds consisting of less than eighteen and thirty-two for the herds consisting of over eighteen cows.

TABLE VII.

Size of herd, labour hours per cow and per 100 gallons (summer and winter).

Group.	*Number of herds.*	*Average number of cows per herd.*	*Number of hours per cow. (Summer).*	*Number of hours per cow. (Winter).*	*Number of hours per 100 gallons. (Summer).*
Size of herd	No.	No.	No.	No.	No.
Under 18	13	11.2	61	108	9
Over 18	13	27.2	98	109	14
Average		19.4	87	109	13

Group.	*Number of hours per 100 gallons. (Winter).*	*Yield per cow in herd.*		*Yield per cow in milk.*	
		Gallons.		*Gallons.*	
Size of herd	No.	Summer.	Winter.	Summer.	Winter.
Under 18	21	302	255	354	326
Over 18	18	340	306	408	374
Average	19	328	293	392	361

A comparison of the yield shows that the larger herds are producing on an average 89 gallons more per cow in herd and 102 gallons more per cow in milk than the smaller herds.

The number of hours per cow and per 100 gallons for summer and winter is set out for the two groups in Table VII. The

months included for the summer period are May to October and for the winter period November to April.

For the reasons already stated, the variation between the summer and winter labour for the larger herds is not very great. Of the labour requirement of 207 hours per cow per annum there is 98 hours for the summer months May to October and 109 hours for the winter months November to April. As regards the smaller herds the difference between the summer and winter requirements per cow is 47 hours. The winter labour for each group is about the same, and over all the herds the annual labour requirement of 196 hours per cow is divided into 87 hours for the summer months and 109 hours for the winter months. Taking the summer period at 184 days, the summer attendance is about twenty minutes per cow (all cows in herd, inclusive of those dry) per day on Group I, thirty-two minutes on Group II, with a

TABLE VIII.

Total labour cost per cow and per 100 gallons, and summer and winter costs.

Group.	*Number of herds.*	*Average number of cows in herd.*	*Cost of labour per cow. (Summer).*	*Cost of labour per cow. (Winter).*
Size of herd	No.	No.	£ s. d.	£ s. d.
Under 18	18	11.2	1 12 8	2 17 0
Over 18	18	27.2	2 18 3	3 4 8
Average		19.4	2 10 10	3 2 6

Group.	*Total cost of labour per cow.*	*Cost of labour per 100 gallons. (Summer).*	*Cost of labour per 100 gallons. (Winter).*	*Total cost of labour per 100 gallons.*
Size of herd	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Under 18	4 9 8	0 5 1	0 11 0	0 16 1
Over 18	6 2 11	0 8 6	0 10 6	0 19 0
Average	5 18 4	0 7 7	0 10 8	0 18 3

general average of twenty-eight minutes for both Groups. For the winter period of 181 days the labour requirement per cow per day is approximately thirty-six minutes for each group and for all herds. The number of hours per 100 gallons of milk produced show similar tendencies to those obtained for the hours per cow, both as regards individual groups and all groups.

Both groups show a higher production of milk during the summer months, but there is a more even distribution between the summer and winter production in the case of the larger herds.

The cost of labour (omitting delivery of milk) varies from £2 15*s.* 8*d.* to £8 18*s.* 9*d.*, with an average of £5 18*s.* 4*d.* per cow. For the herds consisting of less than eighteen cows the rate of wages paid per hour is 6.8*d.* and for the group of over eighteen cows the rate is 7.1*d.* per hour. The average for all herds is 6.9*d.* per hour. These rates of wages include those for women and boys as well as men.

The labour cost per cow and per 100 gallons of milk, together with the summer and winter costs, are given above, Table VIII.

On an average the winter costs represent 55 per cent. of the total annual cost of labour per cow. For the herds of under eighteen cows it represents 64 per cent., and for the herds of over eighteen cows about 58 per cent.

Herd maintenance.

From the cost records obtained during the two years of study the figures at the beginning of years showed that 58 per cent. of

TABLE IX.

Depreciation on cows for two years. (Twenty-six cases).

	Number.	*Total value.*	*Value per head.*
		£ s. d.	£ s. d.
Valuation at beginning of years.			
Cows	505	11,661 3 6	23 1 9
Bulls	18	501 15 0	27 17 6
Purchases.			
Cows	48	846 19 0	19 13 11
Bulls	2	74 0 0	37 0 0
Heifers transferred ...	91	2,059 15 0	22 12 8
Total	659	15,143 12 6	—
Sales.			
Cows	119	2,186 15 3	18 7 6
Bulls	4	98 0 0	24 10 0
Deaths.			
Cows	14	2 0 0	—
Valuations at end of years.			
Cows	506	11,706 17 0	23 2 9
Bulls	16	482 0 0	30 2 6
Depreciation		668 0 3	—
Total	659	15,143 12 6	—

Depreciation per cow £1 6 5
Depreciation per gallon ... ... 0.5d.

the cows were home-bred and 42 per cent. were purchased. The replenishing of the herds on these farms was mainly done by combining rearing with some purchasing. There was only one case where all the cows were purchased, and only four cases where all the herds consisted entirely of home-bred cows. Of the cows and heifers added to the herds during the two years, 68 per cent. of them were home-bred and 32 per cent. were purchased, and of the total, 1,057 cows passing through the herds, 60 per cent. were home-bred and 40 per cent. were purchased.

During the two years 119 cows were sold and fourteen died. The death-rate was equivalent to 2.7 per cent. per annum and 10.5 per cent. of renewals were necessitated by deaths. The figures indicate that 26.3 per cent. of the cows were replaced annually—which means that the average productive life is 3.8 years per cow. Similar results were obtained in the previous study where it was shown that the death-rate was about 3 per cent. per annum, and the cows were kept in the herd for an average period of about three and a half years.

The method by which the depreciation on the cows is arrived at is shown in Table 9.

The variation in the depreciation on cows from farm to farm ranged from an appreciation of £3 2*s*. 9*d*. per cow to a depreciation and re-sale loss of £7 10*s*. 0*d*. per cow per annum. There are indications that the depreciation is higher on the herds consisting mainly of purchased cows than on those where the majority consist of home-bred cows. For thirteen herds with an average of 42 per cent. home-bred cows, the depreciation was £1 17*s*. 3*d*. per cow and 0.77*d*. per gallon, while on the other thirteen herds with an average of 77 per cent. home-bred cows the depreciation was £0 16*s*. 4*d*. per cow and 0.3*d*. per gallon. Again, on the group of farms where the depreciation was under £1 per cow, the home-bred cows averaged 65 per cent., and these fourteen herds showed an average depreciation of £0 2*s*. 5*d*. per cow and 0.05*d*. per gallon. The other twelve herds with a depreciation of over £1 per cow consisted of 54 per cent. home-bred cows and the average depreciation was £2 16*s*. 0*d*. per cow and 0.98*d*. per gallon.

Over the period of two years the average charge for depreciation was £1 6*s*. 5*d*. per cow and 0.5*d*. per gallon. The rate of depreciation is considerably less than that obtained in the previous investigation, where the results over three years showed an average depreciation per annum of £2 8*s*. 0*d*. per cow and 0.96*d*. per gallon. This emphasises the importance of basing conclusions upon results over a period of years, for when the depreciation is

based on results obtained for the five years, the annual repreciation is about £1 17*s*. 3*d*. per cow and ¾*d*. per gallon.

Period of Calving.

The variation in practice with respect to the time when the cows calve is shown in Table X.

TABLE X.

Distribution of calvings throughout the year.

Month.	*Cows freshening.*		*Calves born alive.*	
	Number.	*Per cent.*	*Number.*	*Per cent.*
January ..	25	5.7	23	5.9
February ..	54	12.3	45	11.6
March .	32	7.3	29	7.5
April ...	35	7.9	31	8.0
May ...	33	7.5	29	7.7
June ...	12	2.7	11	2.8
July ..	37	8.4	36	9.3
August	36	8.2	36	9.3
September	52	11.8	46	11.9
October ...	28	6.4	18	4.6
November ..	55	12.5	42	10.8
December ..	41	9.3	41	10.6
Total ...	440	100.0	387	100.0

On a monthly basis, the highest number of calvings occurred in November (12.5 per cent.) and the lowest in June (2.7 per cent.). The high proportion of calvings in July as compared with June is to some measure due to the special demand for milk in some of the areas during the summer season.

The distribution of the calvings as shown in Table X represents the number of calves alive for about one week for sale or transfer in each month during the year. The figures show that in proportion to the number of cows calving only 88 per cent. of the calves are born alive or rearable.

Of the total number of cows calving in the herds, 135 or 31 per cent. calved during the period September to November, 120 or 27 per cent. during December to February, 100 or 23 per cent. from March to May, and 85 or 19 per cent. during June to August. The number of calvings was nearly 35 per cent. higher during September to February than from March to August.

The tables that follow show the relation of time of freshening to costs, production and returns.

In Table XI, two groups were made of the records, one to include herds with less than 25 per cent. and one to include herds of over 25 per cent. freshening from September to November inclusive.

For these particular herds, the results indicate that having cows freshening in the fall does not increase milk production to any appreciable extent. The herds with over 25 per cent. of the cows calving during the months September to November produced about 5 gallons more per cow in herd and 29 gallons *less* per cow in milk than the other group of herds. When the net cost of foods and the net cost of production are considered, it is seen that the farms with the higher percentage of fall freshened cows show the higher costs. But when measured by returns, this group gives the best results.

TABLE XI.

Period of calving (September—November).
Yield and cost of home grown, purchased foods and grazing per cow and per gallon.

Group.	*Number of herds.*	*Average number of cows in herd.*	*Yield per cow in herd.*	*Yield per cow in milk.*
	Number.	Number.	Gallons.	Gallons.
Under 25 %	12	14.6	617.5	772.4
Over 25 %	14	27.6	622.2	743.2
Average		19.4	620.6	752.9

Group.	*Net cost of home grown, purchased foods and grazing per cow.*	*Net cost of home grown and purchased foods per cow.*	*Net cost of home grown, purchased foods and grazing per gallon.*	*Net cost of home grown and purchased foods per gallon.*
	£ s. d.	£ s. d.	Pence.	Pence.
Under 25 %	15 17 5	11 18 8	6.17	4.64
Over 25 %	16 5 2	12 11 7	6.27	4.85
Average	16 2 6	12 7 2	6.23	4.78

Group.	*Total net cost per cow.*	*Balance per cow.*	*Total net cost per gallon.*	*Balance per gallon.*
	£ s. d.	£ s. d.	Pence.	Pence.
Under 25 %	19 16 3	12 16 7	8.15	4.19
Over 25 %	24 9 1	14 18 7	9.26	5.62
Average	23 0 1	18 8 10	8.89	5.21

In Table XII the herds are again divided into two groups and classified according to the percentage of calving from September to February.

The herds with over 50 per cent. of the cows freshening during the period from September to February show a higher milk production, the difference as compared with the other group being seventy-seven gallons per cow in herd and twenty-seven gallons per cow in milk.

TABLE XII.

Period of Calving (September—February).
Yield and cost of home grown, purchased foods and grazing per cow and per gallon (twenty-six herds).

Group.	*Number of herds.*	*Average number of cows in herd.*	*Yield per cow in herd.*	*Yield per cow in milk.*
	Number.	Number.	Gallons.	Gallons.
Under 50 %	11	14.4	583.4	784.8
Over 50 %	15	23.1	660.4	761.1
Average		19.4	620.6	752.9

Group.	*Net cost of home grown, purchased foods and grazing per cow.*	*Net cost of home grown and purchased foods per cow.*	*Net cost of home grown, purchased foods and grazing per gallon.*	*Net cost of home grown and purchased foods per gallon.*
	£ s. d.	£ s. d.	Pence.	Pence.
Under 50 %	11 16 7	11 8 2	6.10	4.69
Over 50 %	16 14 4	12 15 10	6.29	4.81
Average	16 2 6	12 7 2	6.23	4.78

Group.	*Total net cost per cow.*	*Balance per cow.*	*Total net cost per gallon.*	*Balance per gallon.*
	£ s. d.	£ s. d.	Pence.	Pence.
Under 50 %	22 3 3	10 8 6	8.61	4.05
Over 50 %	23 8 10	15 0 10	8.55	5.22
Average	23 0 1	13 8 10	8.89	5.21

As regards cost of foods, total cost of production, and returns the figures show the same general tendencies as in Table XI, that is, that the higher cost of foods and higher production costs which accompany the relative high autumn and winter calving is more than compensated by the higher returns obtained.

Receipts and Expenses.

Receipts vary according to the methods of selling and the price received for the milk. The method of disposal of milk is shown in Table XIII.

TABLE XIII.

Method of disposal of milk over two years.

Method of disposal.	*Per cent.*	*Per cent.*
Wholesale	69.8	
Retail	14.9	
		84.7
Butter-making and cream	8.9	
Cheese-making	0.2	
Household	2.4	
Calf-rearing	3.6	
Other milk	0.2	
		15.3
		100.0

The average price received per gallon for wholesale milk was 14.8*d.* per gallon, and for retail milk 21.6*d.* per gallon. On the basis of the gallons used and the price realised for milk products, the average price for milk utilised for butter and cream was 8.9*d.* and for cheese 10.7*d.* per gallon. Prices vary from farm to farm and these reflect differences in the quantities of milk sold in the various categories as well as differences in the average price obtained for the same class of milk. For wholesale milk the average price per annum varied from 9.7*d.* to 17*d.* per gallon, and retail milk from 15.2*d.* to 27.6*d.* per gallon. The values realised for milk used for butter and cream ranged from 6*d.* to 21*d.* per gallon, and for cheese from 6.7*d.* to 12*d.* per gallon.

A summary of the receipts and expenses for the twenty-six cases is given in Table XIV.

TABLE XIV.

Receipts and Expenses.

EXPENSES.	*Per Cow.* £ s. d.	*Per gallon.* Pence	RECEIPTS.	*Per Cow.* £ s. d.	*Per gallon.* Pence
Gross cost of production ...	25 13 8	9.92	Receipts for milk and milk products ...	39 1 11	15.12
Delivery costs ...	2 13 0	1.02	Calves, manurial value of foods and service fees ...	2 13 7	1.03
Total expenses ...	28 6 8	10.94			
Balance ...	13 8 10	5.21			
	£41 15 6	16.15		£41 15 6	16.15

Receipts averaged £41 15*s.* 6*d.* per cow and 16.15*d.* per gallon. The lowest was on a butter producing farm with an

average of £18 14*s.* 3*d.* per cow and 10.34*d.* per gallon. The highest receipts were £71 19*s.* 8*d.* per cow and 24.8*d.* per gallon. In this case, all the milk produced was Grade A and was retailed. The total expenses averaged £28 6*s.* 8*d.* per cow and 10.94*d.* per gallon, with variations of from £14 8*s.* 11*d.* to £55 1*s.* 0*d.* per cow and from 6.4*d.* to 19*d.* per gallon. The difference between receipts and direct expenses averaged £13 8*s.* 10*d.* per cow and 5.21*d.* per gallon. This varied from 10*s.* 5*d.* per cow and 0.31*d.* per gallon to £37 5*s.* 6*d.* per cow and 12.88*d.* per gallon. No allowance has been made for interest on capital. The average capital directly invested in dairy livestock and equipment on these twenty-six herds was approximately £13,896 and at 5 per cent. per annum the interest charge would amount to £694 or £1 7*s.* 6*d.* per cow and 0.53*d.* per gallon. The manual work done by the farmer and any member of the family has already been included under production labour. The amount, therefore, remaining for management and profits would be as follows :—

	Per cow.	*Per gallon.*
Balance	£13 8 10	5.21d.
Less interest on dairy capital	£ 1 7 6	0.53d.
	£12 1 4	4.48d.

As all home-grown feeds have been entered at estimated costs of production, the balance remaining has to cover general profits or management and interest on capital over the production of these feedstuffs, which represent a considerable portion of the total enterprise of each of the farms.

APPENDIX.

Number of cases — 26. Number of cows in herd - 505. Number of cows in milk — 416. Number of cows dry — 88. Total milk yield — 313.567 gallons. Average milk yield—621 gallons. Per cow in milk—753.

HERD TRANSACTIONS.

	£ s. d.	£ s. d.		£ s. d.	£ s. d.
Valuation.			*Sales.*		
505 cows, 20 bulls		12,162 18 6	119 cows, 4 bulls	2,284 15 3	
Equipment		1,808 10 8	1 carcase	2 0 0	
Purchases.					2,286 15 3
48 cows	846 19 0		*Valuation.*		
91 home-bred heifers transferred	2,059 15 0		506 cows, 16 bulls		12,188 17 0
2 bulls	74 0 0		Equipment		1,630 19 3
		2,979 14 0	By Depreciation		845 11 8
		£16,951 8 2			£16,951 8 2

	£	s.	d.		£	s.	d.
To Depreciation ...	845	11	8	By value of 387 calves	1,037	9	2
,, Home grown foods	8,154	19	8	,, manurial value of food consumed ...	305	6	10
,, Purchased foods ...	3,394	1	6	,, service fees ...	12	10	0
,, Pasturage ...	1,903	0	0	,, 219,011 gals. (wholesale) ...	13,574	16	1
,, keep of bull and cost of service ...	370	2	7	,, 46,626 gals. (retail)	4,218	3	3
,, Labour ...	2,864	11	10	,, 27,947 gals. (butter-making and cream)	1,046	6	3
,, Miscellaneous ...	444	4	10	,, 544 gals. cheese-making) ...	24	8	4
,, Cost of delivery ...	1,388	4	11	,, 7,668 gals. (household) ...	296	1	5
,, Balance ...	6,793	1	8	,, 11,277 gals. (calf-rearing) ...	489	10	11
				,, 492 gals. (other milk) ...	5	8	10
				,, 17,987 gals. (separated milk) ...	149	17	10
				,, 960 gals. (butter-milk) ...	2	0	0
				,, 287 gals. (whey)	1	3	11
	£21,107	17	10		£21,107	17	10

LABOUR REQUIREMENTS OF CROPS ON WELSH FARMS.

By J. Llefelys Davies, M.Sc.,

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In most farming districts in Wales the cultivation of arable crops for stock feed is still an important enterprise. Acreage of crops has been reduced considerably in some areas during recent years, but it is unlikely that arable crops will be reduced much further while the present mixed husbandry system remains. Almost the whole of the output of these mixed farms comes from the sale of livestock and their products, and the greatest proportion of the normal supply of labour on farms is directly devoted to the feeding and management of the livestock. Nevertheless, the provision of feedstuffs in the form of arable crops and hay forms an important part of the farm economy. The seasons of greatest demand for labour in crop cultivation and harvest coincide with the period of least demand for direct livestock labour. The concentration of work in the fields occurs in late spring, summer and early autumn, while the work of attendance on livestock is concentrated in the winter months. On most farms there is a delicately arranged balance of enterprises, organised to utilise labour time as effectively as possible. This balance of enterprises is one of the important factors in the

general economy of the farms. Horse labour, however, cannot be utilised directly on livestock to any great extent, and the costs of maintenance of horses are justified largely by results from crops harvested.[1]

The importance of crop enterprises from the point of view of use and efficiency of labour is illustrated in the following Table showing on broad lines distribution of labour time on sixteen mixed farms. This sample represents a fairly uniform system of farming in Wales, but the individual farms exhibit variation in size from about 50 to about 300 acres. With the exception of two hill sheep farms all can be described as lowland farms, some with medium and others with poor quality land. The average farm in the group is about 130 acres in size, carrying about four work horses and three others. About thirteen dairy cows and thirty other cattle, mainly stores of all ages, about one hundred breeding ewes and two breeding sows. Slightly more than half the cultivated area in the average farm is utilised for pasture, 26 per cent. for hay, and about 23 per cent. for tillage crops.

Percentage distribution of manual and horse labour. (Average two years).

	Man labour. Percentage of total time.	*Horse labour. Percentage of total time.*
Direct livestock labour	48.7	3.2
Cereals	11.8	37.0
Root crops	14.1	33.5
Pasture and hay	7.7	13.9
Total land and crops	33.1	84.1
Establishment	14.2	6.9
Miscellaneous	4.0	5.5
	100.0	100.0

The information regarding distribution of labour was collected for the period 1925-7. Detailed time-sheet records of all the work done on the farms were kept throughout the period.

[1] This study is one part of a general investigation of conditions of economy of labour on farms in Wales. Other parts which may be read in connection with statements here are :--

Davies. Horse Labour on Welsh Farms, 1887-1927. This *Journal*, Vol. VI, 1930.

Davies. Seasonal Distribution of Manual and Horse Labour on Welsh Farms. This *Journal*, Vol. VII, 1931.

Davies. Labour Aspects of Farm Layout in Wales. This *Journal*, Vol. VII, 1931.

and all figures of labour requirements have been derived from the analysis. On these farms the labour devoted to land and crops amounted to about one third of total manual labour and more than four-fifths of the total horse labour used. These proportions varied from farm to farm, the lowest and highest percentages for manual labour being 24 and 44, and for the horse labour 73 and 98 respectively.

The amount of tillage and hay land on the farms largely determines the number of work horses maintained. There are variations in the use made of horses in productive work, but the number necessary depends on the peak load to be carried in the spring and summer with tillage and hay crops. The intensity of use of manual labour on these farms depends primarily on the intensity of stocking, especially with cattle. Other secondary factors are the size and layout of the farm.[2]

Labour requirements of Cereals.

Records of labour used directly on crops refer to two complete cropping cycles extending from May, 1925, to December, 1927, and they cover all the processes from the preliminary cultivations to stocking and threshing. In the analysis of the records, the amounts of labour on each of the principal crop operations have been kept separate, and classification of operations coincides as far as possible with divisions recognised in farm practice. These are the labour items which would be included in the costs incurred in the complete production of the specified crops, but they would not always be incurred within one calendar or one accounting year. These figures have to be interpreted always with reference to the special circumstances of layout of farms, topography of land, size of farms and size of plots arranged for tillage purposes.[3] The average size of plot cultivated for cereals on these farms was 4.9 acres, but there was a considerable range in size from an average of 2.4 acres per plot on small farms or those with very small tillage acreages to 6.8 acres on the larger holdings.

The Table below gives the average man and horse labour requirements per acre for the principal cereals on the basis of

[2] *Op. cit.* Labour Aspects of Farm Layout.

[3] Total requirements for crops here presented differ slightly from similar figures published in " Farm and Market ", Vol. 1, No. 4, but those were based on 1925 and 1926 records, whereas the present figures refer to two complete cropping years, 1925-6 and 1926-7. The differences in results occur mainly with root crops, and requirements for these crops are subject to considerable variations from year to year.

separate operations. The average acreage of each cereal grown on these farms was :—

	Acres.
Wheat	4.1
Oats	11.0
Barley	6.7
Mixed corn	4.8

But, as indicated above, these areas often represented more than one plot.

Man and horse labour on cereal crops. Hours per acre.

Operations.	*Oats.*		*Barley.*	
	Man.	*Horse.*	*Man.*	*Horse.*
Ploughing ...	13.5	27.5	12.4	25.0
Cultivating and cleaning ...	8.9	15.0	10.0	18.4
Manuring ...	1.3	0.7	1.9	1.3
Planting ...	1.5	1.3	1.5	1.6
Weeding and spraying ...	0.6	--	0.6	—
Cutting and stooking	19.7	6.5	17.4	5.4
Carting and thatching	12.1	6.0	13.3	6.4
Threshing ...	4.3	0.3	13.7	0.8
Miscellaneous ...	0.3	-	0.4	0.2
Total ...	62.5	57.3	71.2	59.1

Operations.	*Wheat.*		*Mixed corn.*	
	Man.	*Horse.*	*Man.*	*Horse.*
Ploughing ...	12.2	24.8	13.1	27.1
Cultivating and cleaning ...	6.0	13.1	8.0	15.1
Manuring ...	3.1	1.8	2.2	2.0
Planting ...	2.1	2.4	1.4	2.2
Weeding and spraying ...	0.8	—	0.1	—
Cutting and stooking	11.9	6.2	17.8	4.8
Carting and thatching	12.0	5.1	12.1	6.1
Threshing ...	13.0	1.0	10.1	0.1
Miscellaneous ...	—	—	—	—
Total ...	61.1	54.4	64.8	57.4

The figures in each case are averages of requirements over the group as a whole. Extreme variations occur on individual farms, in some cases arising out of natural causes, such as stiff soil and wet conditions or hilly fields or bad harvest conditions,

but in others due to poor teams and equipment and ineffective labour or poor use of available resources. The average requirements for each operation and for the crop totals are indicative only of the present position on the representative farm in Wales. The requirements are high compared with some standards in English areas and especially in other countries.

Labour requirements for ploughing are fairly uniform over the whole range of cereals, and in most cases they cover more than once over. Some fields are only ploughed once, others are ploughed in the autumn and again in spring. The operations termed cultivating and cleaning cover harrowing, with some actual cleaning and rolling, both before and after planting. Comparatively little hand weeding is done nowadays on Welsh farms, and the figure given to cover weeding and spraying are not representative of the time it would take to carry out these operations properly. Only a few farms, however, had any entries for these items, and the average requirements indicate only conditions for the sample as a whole. There were only two cases of spraying, both for eradication of charlock in the oat crop.

Taking the group of cereals as a whole these average requirements were found :—

Average labour requirements of all cereal crops.

	Hours per acre.		*Percentage of total.*	
	Man.	*Horse.*	*Man.*	*Horse.*
Ploughing ...	12.9	26.1	19.8	45.8
Cultivating and cleaning ...	8.3	15.4	12.8	27.0
Manuring ...	2.1	1.4	3.3	2.6
Planting ...	1.6	1.9	2.5	3.3
Weeding and spraying ...	0.5	—	0.8	—
Cutting and stooking	16.8	5.8	25.8	10.0
Carting and thatching	12.4	5.9	19.0	10.3
Threshing ...	10.2	0.5	15.7	0.9
Miscellaneous ...	0.2	—	0.3	0.1
Total ...	65.0	57.0	100.0	100.0

In considering the total requirements, it is interesting to notice that there is greater use of manual than of horse labour. More horse labour is used in the preliminary occupations of ploughing and after cultivation, but considerably more man hours are involved in harvesting and preparing the grain for use. On

most of these farms the single furrow plough is used regularly, drawn mainly by a pair, but sometimes by three horses in difficult ground. Of the sixteen farms, eleven had self-binders and one shared this machine with a neighbour, while four handled the harvest with the reaper and the scythe. Three of the latter were less than a hundred acres in size and had only small plots of tillage.

Root Crops and Potatoes.

Reference to Table on p. 27 shows that these crops actually utilise more man labour and only slightly less horse labour on these farms than cereals. As a general rule on farms of this mixed character the arable rotation is designed to maintain the pasture fields in good condition. One or two fields are broken to the plough each year and a similar number laid down to grass for a period of from five to ten years, depending on the nature of the soil and the land available for arable crops. By means of this long period of pasture, the rotational system, although the actual tillage area is small in proportion to total, is effective in treating each field at fairly regular intervals. In many districts a periodic cleaning of fields by tillage and temporary cropping has been considered essential to the production of good pasture. The introduction of roots into the rotation gives the opportunity for utilisation of farm yard manure and for thorough cleaning of the land prior to laying down to fresh grass seeds. The amount of labour given to the root crops, including potatoes, is high, partly because of their own requirements, but also partly for the purpose of laying the foundations of a " good heart " in the land for future grazing. In this investigation the potato crop is included in the root break. Usually a whole field is divided into small plots to carry the different crops. The first ploughing will be done for the whole field, but all other operations, including manuring, will be done for each crop separately at the planting season. In most farms the bulk of the farmyard manure is given to the root crops, and it is generally carted direct to the drills before planting. Heavy applications up to twenty tons per acre are common both for potatoes and mangels, although there are signs that on some farms the farmyard manure is nowadays spread more thinly over large sections of the farm, and greater reliance is placed on artificials for the potato and root crops.

Where the total tillage area is small the root break will only extend over a small area, and the plots for each separate crop will be hardly greater in size than good gardens. These small plots are difficult to work efficiently and are very wasteful of man

and horse labour. The average acreage of root crops grown per farm was as follows :—

	Acres.
Potatoes	1.8
Mangels	1.2
Swedes and turnips	2.5

In some cases the root break covered parts of two fields, and in other cases two small fields, so that the plots for each crop were tiny and the labour involved in cultivation unduly heavy. The average requirements of labour for these crops are set out in the Table.

Hours of man and horse labour per acre on roots and potatoes.

Operation.	*Potatoes.*		*Mangels.*		*Swedes.*	
	Man.	*Horse.*	*Man.*	*Horse.*	*Man.*	*Horse.*
Ploughing ...	19.3	38.6	24.1	48.3	21.7	41.6
Cultivating ...	11.3	21.6	19.7	38.3	17.1	31.4
Manuring ...	49.5	34.0	51.7	36.9	38.7	26.1
Ridging and planting	24.5	15.4	12.8	20.0	10.8	16.2
Hoeing and weeding	44.8	16.6	131.1	9.0	85.5	6.7
Lifting and carting	120.2	35.6	93.0	39.1	50.7	22.0
Sorting and marketing ...	30.8	4.5	-	—	—	—
Miscellaneous ...	—	—	0.2	0.2	0.3	0.3
Total ...	300.4	166.3	332.6	191.8	224.8	147.3

With each of these crops it has been usual to plough twice, in the autumn and in the spring in preparation of the land for planting, but the modern tendency with cultivation for roots is to depend less on double ploughing and to utilise to a greater extent heavy cultivators and spring harrows for the preparation of tilth. With root crops and potatoes the work involved in manuring is very heavy, amounting to about one-sixth of the total manual and more than a fifth of the total horse labour requirements. Time requirements for hoeing and weeding are especially heavy with mangels and swedes. This shows considerable variation according to the nature of the season, and during wet summers almost unlimited labour can be utilised without cleaning the land successfully. The high normal rainfall in most districts in Wales necessitates a high labour requirement for root crops. Weeds grow profusely both in the pasture fields and in the cereal crops, and the work of periodic cleaning after long intervals becomes very heavy. In dry seasons labour requirements for roots and

potatoes are low, and also the hay harvesting is done easily and with dispatch. Labour in the summer months can be utilised under these circumstances for other useful farm tasks, which often do not enter in the normal scheme of work.

The requirements for lifting and carting potatoes are high, partly because the crop on some holdings was lifted by hand, and in others by the aid of the ridging plough. Only the larger farms used the mechanical lifter. Some farms still employ large numbers of casual workers and helpers from neighbouring holdings for this operation, and it is not infrequent to find up to forty pickers in a small field. The lifting is done in a short time in this way, but the total hours of labour used are unduly high.

The percentage distribution of labour time between the principal operations on these crops were as follows :—

	Potatoes.		*Mangels.*		*Swedes.*	
	Man.	*Horse.*	*Man.*	*Horse.*	*Man.*	*Horse.*
Cultivations ...	10.1	36.3	13.1	45.2	17.3	51.7
Manuring and planting ...	24.7	29.6	19.3	29.6	22.1	28.8
Hoeing and weeding	14.9	10.0	39.5	4.7	38.0	4.5
Harvesting ...	50.3	24.1	28.1	20.5	22.6	15.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

The term " harvesting " includes actual lifting and carting of produce to the clamps or place of storage; and, with potatoes, the work of opening and closing of clamps and some sorting and marketing. The work of preparing roots for feed has been charged directly to the livestock concerned.

Other crops of some importance on Welsh farms, and which are frequently introduced as part of the root break, are Rape and Kale. One of these crops was grown on seven holdings in this sample for two cropping years. Occasionally either of these crops may be grown on a reclaimed field or may be used as a nurse crop for seeds in a field that is not treated as part of the normal rotation. Normally these crops receive only light dressings of farmyard manure, or they may be grown entirely with artificials. The average area planted on these seven holdings was about 8 acres annually.

Cultivations, taking ploughing and other cultivating together, are approximately as intensive as those for swedes. In

all cases these crops were consumed either by sheep or cattle directly off the land.

Labour requirements of rape and kale crops.

	Hours per acre.		*Percentage of total.*	
	Man.	*Horse.*	*Man.*	*Horse.*
Ploughing ...	26.8	56.4	37.8	53.3
Cultivating ...	13.6	28.8	19.0	27.2
Manuring ...	15.7	10.8	22.2	10.3
Ridging and planting	6.1	7.3	8.7	6.9
Hoeing and weeding	8.0	2.1	11.2	2.0
Miscellaneous ...	0.8	0.3	1.1	0.3
Total ...	71.0	105.7	100.0	100.0

Labour requirements of Hay and Pasture.

Most of the work devoted to these crops occurs during the hay harvesting season in June and July. During this comparatively short period all labour is concentrated on harvesting operations, and in a favourable season most of the work is over in about three weeks. Bad weather, however, frequently delays and complicates operations and largely increases labour requirements. Before the introduction of harvesting implements, such as the mowing machine, swathe turner and mechanical lifter, work on the hay involved the aid of large numbers of casual workers, and in times of stress, of exchange of labour between farms in the

Labour requirements of hay crops.

	Hours per acre.		*Percentage of total.*	
	Man.	*Horse.*	*Man.*	*Horse.*
Cultivations ...	0.6	1.1	2.5	9.6
Manuring ...	2.2	1.2	9.5	11.2
Cutting ...	3.3	2.9	14.3	26.4
Harvesting ...	14.2	5.6	61.4	50.1
Thatching ...	1.5	0.1	6.4	0.9
Miscellaneous ...	1.2	0.2	5.9	1.8
Total ...	23.0	11.1	100.0	100.0

same district. This served to delay harvest operations and increase the labour used on the crop enormously. At present however, most fair sized farms manage the crop with the use of

machinery and the normal labour staff, but on small farms, and in some districts on large farms, the system of exchanging labour still exists and the figures of labour requirements do not always bear a close relation to the actual needs of the harvesting process.

The operations on pasture consist mainly of manuring and thistle cutting, and the amounts used per acre only amount on the average to about 1½ man hours and ½ hour of horse labour. The requirements of labour for hay on individual farms vary fairly closely with the total hay acreage. On the smallest farm with only seventeen acres under hay the man hours used per acre were thirty-six and the horse hours fourteen, while on another farm with a total of fifty acres of hay the requirements were twelve man hours and eight and a half horse hours per acre. The time requirement shown for thatching hay covers in most cases the trimming and general work done in the hay shed. Eleven farmers in the sample had hay sheds, and in the five without sheds the average time requirement for thatching was about three man hours per acre.

General.

One of the most striking features revealed by the analysis of this data of labour requirements is the remarkable variation shown by individual farms, even for definite simple operations on crops. Labour requirements on crops vary fairly closely with size of farm and acreage under tillage crops. But even small farms with light land which is easily cultivated may have lower requirements per acre than larger farms with heavy, wet, or hilly land and inconvenient layout. All the physical features of the farms have their effects on labour time taken for any given operation. But heavy land, which is frequently expensive to cultivate, may give high yields of crops with regularity, whereas a light land field may show low labour time used, but give much lower yields of grain and straw than the former.

Variations again arise directly from the differences in the quality of horse teams used and the implements and machinery placed at the disposal of the man and horse power. This feature is particularly evident in some of these farms with operations such as hay harvesting, and cultivation for root crops. Managerial ability of the farmer in direction of labour and in its effective use is an important feature which is disclosed, although it cannot be separately measured in the amounts of labour utilised for crop operations. The weather is another important influence which either makes for smooth working and easy dispatch of plans, or disorganises completely the organisation of labour for work on

crops, frequently carrying forward the operations "out of season" and making the work therefore ineffective and costly.

The figures presented above show, in the first place, the importance of crop labour in the economy of mixed farms in Wales. There is no attempt to suggest what requirements for operations should be; this necessarily is a question that can be decided only with strict reference to conditions on individual farms. The average requirements set out in the tables can only be applied under normal conditions on representative holdings comparable with the average farm in this sample. Requirements for individual operations on crops will always show considerable variation from farm to farm and in different seasons, but the distribution shown in this present study illustrates fairly the general position.

Many farmers of mixed holdings have curtailed tillage acreage in recent years, but on farms of this category there are many points to be considered before such a step can be warranted on the basis of cost measured by labour time alone. The tillage acreage forms an integral part of pasture management and maintenance of fertility and general condition of the whole farm. Crops are grown, in many cases, nearly as much for the use that is made of straw as of the grain. The labour supply both in men and horses is maintained and organised for a definite schedule of operations at different seasons of the year, and the crop land cannot be seriously curtailed without a great deal of disorganisation and possibly less effective use of labour. There is certainly room for better cultivation of crops and in many cases for better and more economical use of labour in handling them. But any considerable change in utilisation of land on these farms should be carefully considered from all aspects, and it is impossible to dissociate changes in arable land from the general production of the farm or from the use of total supply of labour power.

BY-PRODUCTS OF THE CATTLE INDUSTRY.

PRICES AND SUPPLIES OF HIDES.

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The utilisation of the hides and skins of animals by human beings for various personal and domestic purposes dates from the earliest times. References are made in early literature to the

trade in hides in Eastern countries. "The Egyptians employed leather for most of the purposes for which we use it to-day, and they taught their methods to the Hebrews, who in turn were the first to discover the value of oak bark in tanning. Homer's *Iliad* described the oldest form of good tanning, the 'Shamoying' process, whereby the pores of the hides are opened by repeated washings and thereafter oil is forced into it by beating and rubbing while the hide is stretched and staked out, the whole taking about two hours work. Our present methods of making hides and skins into leather are therefore, the result of tens of centuries of experience and forgotten failures".[1] In this country the industry is old established, and up to comparatively recent times most large villages had their tanneries, where the hides from local cattle were tanned and the leather produced was utilised by local bootmakers and saddlers. The organisation of the industry has now changed, most of the small local units have disappeared, and the manufacture of leather is mainly undertaken by large units situated in the principal consuming centres. In 1926 only four tanneries handling cattle hides were enumerated in Wales. Even these do not deal in local hides exclusively. Increasing proportions of imported hides are purchased, and there is a general tendency in favour of purchasing graded hides at the central hide markets of England. On the other hand, hides from slaughter-centres in Wales are sent direct to English tanneries or *via* the hide markets in the great consuming centres in South Wales and those in the border towns for North Wales. The technical processes of the tanning industry have undergone rapid changes since the beginning of this century, and the small village tanneries with old-fashioned methods have been gradually eliminated through economic pressure and failure to adopt new practices.

Supplies of Hides.

Although farm animals are not reared normally for the sake of the skin, the trade in hides and skins both within the country and in international commerce is of considerable importance. The annual world production of hides and calf skins is estimated at about 91,000,000 pieces. Of this total more than two-thirds is manufactured into leather in the five principal leather producing countries, United States, United Kingdom, Germany, France and Italy. These manufacturing nations draw supplies from farming countries such as Argentina, India, China and Brazil, which they utilise in addition to their native hides. As a result

[1] Clemen. By-products in the Packing Industry, p. 12.

there is export and import of leather in the different countries on a large scale, so that although the hide is a by-product of the meat trade, and often little thought of by the farmer, and sometimes the butcher, it is an article of great value to every agricultural and industrial community.

This country is one of the foremost in leather manufacturing. In total production of leather of all kinds at present it is second only to the United States. The hides for heavy leather are partly home slaughtered and partly imported. The number of home slaughtered hides available in the United Kingdom in 1928 was approximately 2,800,000 from cattle and 1,100,000 calf skins.

These supplies are subject to small variations from year to year, according to the actual slaughterings of home reared cattle, the number of natural deaths, and the imports of live store and fat cattle (principally from Ireland) into this country. Variations over long periods may, however, be considerable, depending on the trend of cattle production and the demand for meat. This is illustrated in the Table below, showing estimated slaughter in England and Wales at two periods and in some individual years.

Estimated number of cattle sold off farms for slaughter.[2]

		Cattle.	*Calves.*
Average	1909-13	1,381,000	536,000
	1920-21	1,251,000	728,000
	1921-22	1,125,000	729,000
	1922-23	1,254,000	854,000
	1923-24	1,262,000	826,000
	1924-25	1,231,000	791,000
Average	1921-25	1,225,000	785,000

It is interesting to note in the Table that although slaughter of cattle was less in the post-war than in the pre-war period, the number of calves slaughtered has increased by about a quarter of a million annually.

It is difficult to arrive at a figure of average weight of green hide produced because of the variety of cattle differing in age, size and breed that are converted into meat. The official estimate used in 1908 was 70 lb. for cattle and 12 lb. for calves.[3] An average of 62 lb. hide weight for cattle and 12 lb. for calves is the best estimate it has been possible to obtain to represent the conditions in recent years. Using these figures, the total weights

[2] Agricultural Output of England and Wales, 1925, p. 59.
[3] Agricultural Output of Great Britain, 1908, p. 12.

of home produced hides available in England and Wales in recent years are :—

				cwt.
Cattle	...	...	...	1,310,000
Calves	...	...	...	120,000
Total	...	...	...	1,430,000

A proportion of the home supplies of hides is exported each year in the raw state, but this trade has declined during recent years, and the exports take the form of leather in various stages of manufacture. A statement showing the average imports and exports of hides for three five-year periods, and the quantities retained for leather manufacture in this country are given below.

Imports and exports of hides: United Kingdom.

	1900-04.		1909-13.	
	Quantity.	*Value.*	*Quantity.*	*Value.*
	Cwt.	£	Cwt.	£
Gross imports ...	1,000,403	2,556,600	1,335,733	4,661,869
Re-exports ...	341,008	915,028	469,339	1,689,776
Retained imports ...	659,400	1,641,572	866,394	2,972,093
Exports, U.K. produce ...	172,776	346,780	237,511	701,456
Net balance of imports ...	486,624	1,294,792	628,883	2,270,637

	1925-29.	
	Quantity.	*Value.*
	Cwt.	£
Gross imports ...	1,519,137	6,649,759
Re-exports ...	416,049	1,788,665
Retained imports ...	1,103,088	4,861,094
Exports, U.K. produce ...	143,586	517,861
Net balance of imports ...	959,502	4,848,233

The actual balance of imports retained in this country for manufacture was much greater in the years 1925-9 than in either of the other periods cited in the Table. Imports and exports for the Irish Free State were included in the totals for the two earlier periods, but the dimensions of the trade were such as to make little or no difference to the final figures for purposes of comparison. Although the supplies of home slaughtered hides have tended to be smaller in recent years than in the pre-war period,

the quantity exported has diminished, so that home supplies available to the industry have been about maintained. The leather industry, however, has increased and the approximate measure of that increase is found in the trend of quantities of retained imports.

According to the *Census of Production, 1924*, the output of the heavy leather trades in that year was appreciably greater than in 1907. In undressed leather the increase in value of output was 74 per cent., while in dressed leather it was more than double the 1907 output figure. Prices were appreciably higher in 1924, but even allowing for this there was considerable increase in production and output in all branches except in the production of leather belting.[4] Total number of persons employed in the leather industry were 30,458 in 1924 as compared with 28,671 in 1907. But horse power employed had increased from 22,495 in 1907 to 40,747 in 1924, and electric power from 1,568 to 9,815 kilowatts.

The principal sources of supplies of hides into this country in recent years have been Germany, France, Italy, Ireland, South and East Africa, Argentine, New Zealand, and Australia.

Prices and Price Movements.

The prices received by the butcher or meat wholesaler for cattle hides seldom appears to be a matter of direct interest to the farmer. The values of the by-products are included in the price paid for the fat animal. Nevertheless, prices realised for by-products and profits earned in the industries concerned in the utilisation of by-products do affect materially the prices paid to the farmer as the primary producer of livestock. The connection between values of by-products and prices paid for fat stock is not as apparent in this country as in some other countries, notably the United States, where the great central packing houses handle the greater part of the meat. These organisations operate on a very large scale, and this enables them to make the greatest possible use of all the by-products, either by manufacture direct in the same organisations or by transfer to other units or subsidiary organisations. In this country, on the other hand, although killing is carried out at some central abattoirs on a fairly large scale, the hides belong to numerous owners; but probably the greater part occurs on private premises both in towns and villages, and there cannot be the same degree of specialisation in the use of all by-products as when operations

[4] Third Census of Production, 1924. Preliminary Report, No. 20. *Board of Trade Journal*, July 28, 1927.

are conducted on a large scale. Better care and utilisation of by-products means a better return to the butcher and incidentally to the farmer. Of all the by-products of the meat trade the hide is of greatest value, and care should be exercised on the farm and at the slaughter-house that its qualities are not impaired by inefficient flaying or by lack of attention to warbles and other defects or skin diseases.

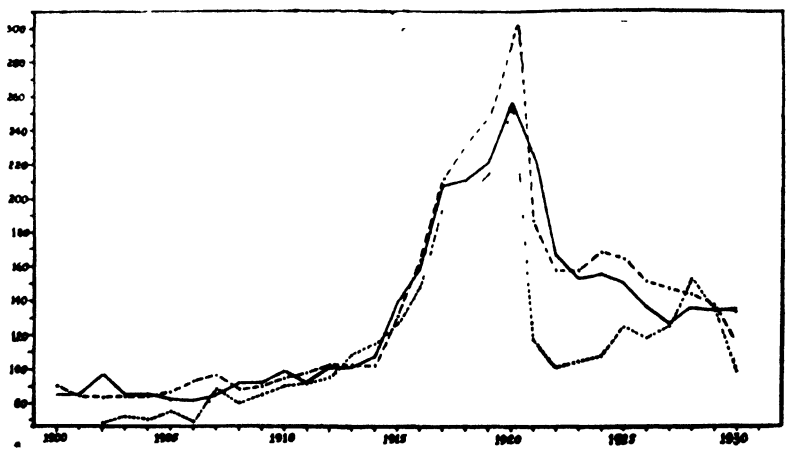
Hides are classified in the trade into many grades and designations. In the first place they are divided according to weight into heavy and light cattle hides; kips; and calves. Distinction is further made according to whether the hides are ox, heifer, cow, bull, calves. The nature and the quality of hides from these different categories of animals differ even in uniform weight classes. Secondly, classification depends on whether the hides are warble free or not, several degrees of warble infection being recognised in the different grades. Thirdly, the grading has to recognise the varying degrees of moisture in hides, and prices differ for green and dry hides. Several methods of preservation and curing again are recognised in the import trade. Finally hides of breeds of stock vary in quality and suitability for definite purposes, and the influence of environment is recognised in hide quality by the classification made according to geographical district. All the factors entering into quality are recognised in the trade, and marketing is carried on principally by inspection or by the experience of and confidence in the grading of particular organisations. Any study of hide prices covering a long period is therefore fraught with difficulties arising from changes in quality, grading, and description. In addition the quality of hides varies with the seasons, being generally better in summer than in winter. This applies particularly to the hides of home produced stock.

As hides are definite by-products of the meat industry, their prices do not follow the common course of those subject to the influence of direct supply and demand. The demand for hides may increase and yet the supply cannot extend at a faster rate than the slaughter of cattle allows. On the other hand demand may fall seriously and yet supply is not curtailed though prices drop to very low levels. This peculiarity often causes extreme fluctuations in hide prices without affecting the course of supplies. To some extent the element of speculation has diminished of recent years, as attempts have been made by the organisations concerned to control conditions of demand with the object of reducing risk in a trade in which the turnover is slow and price fluctuations naturally have a serious effect.

The course of general hide values from 1900 to 1930 may be followed in Diagram I. Here the prices quoted are the figures of average import prices which are included in the *Statist* index number. These do not represent exactly the returns for home produced hides in English markets, but they serve the purpose of showing the trend of hide values. On the whole the trend of prices was definitely upwards in the years before the war, and after the period of abnormally high prices during the war, prices were low from 1921 to 1924, only to rise again gradually to a peak in 1928. Since 1928 values have fallen steadily to reach very low levels in 1931. A closer analysis of recent price quotations and especially the trend since 1929 can be seen in Table. p. 46. An index of prices of middling English beef and the *Statist* index of general level of prices are presented for comparison in Diagram I.

DIAGRAM I.

Indices of Prices, 1900-1930.



Average 1910-1914 = 100.

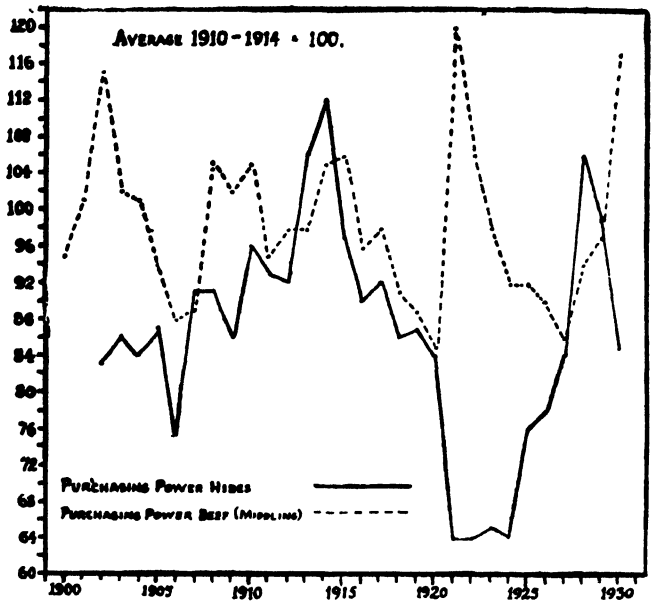
Wholesale prices - - - - Beef (middling)———— Hides . . . . .

Prices of hides were relatively lower than beef prices from 1902 to 1910, but the trend in both cases was upwards. The curves for hide and beef prices follow the index of general prices from 1910 to 1916. From 1916 to 1920 hides and beef prices move together at a lower level than the index of general prices. With the coming of free markets in 1920 hide prices fell to a lower level than beef prices and the discrepancy was very marked from 1921-1926. The two curves meet again in 1928, but hide prices have fallen further in 1931.

The actual comparison between hide and beef prices over this period is brought out more clearly in Diagram II, showing the purchasing power of the two commodities.

DIAGRAM II.

Purchasing power of hides and beef, 1900-1930.



The course of hides prices for long periods can be seen in the following table of average prices for River Plate salted hides and average declared values of imports :—

	River Plate salted hides.	*Average declared values of imports.*
	Pence per lb.	Pence per lb.
1867-77	7	$6\frac{7}{8}$
1878-87	$6\frac{3}{4}$	$6\frac{1}{2}$
1890-99	$5\frac{1}{2}$	5
1904-13	$7\frac{1}{2}$	$6\frac{7}{8}$
1914-20	$14\frac{1}{2}$	$14\frac{1}{3}$
1921-29	$9\frac{1}{8}$	$9\frac{3}{5}$

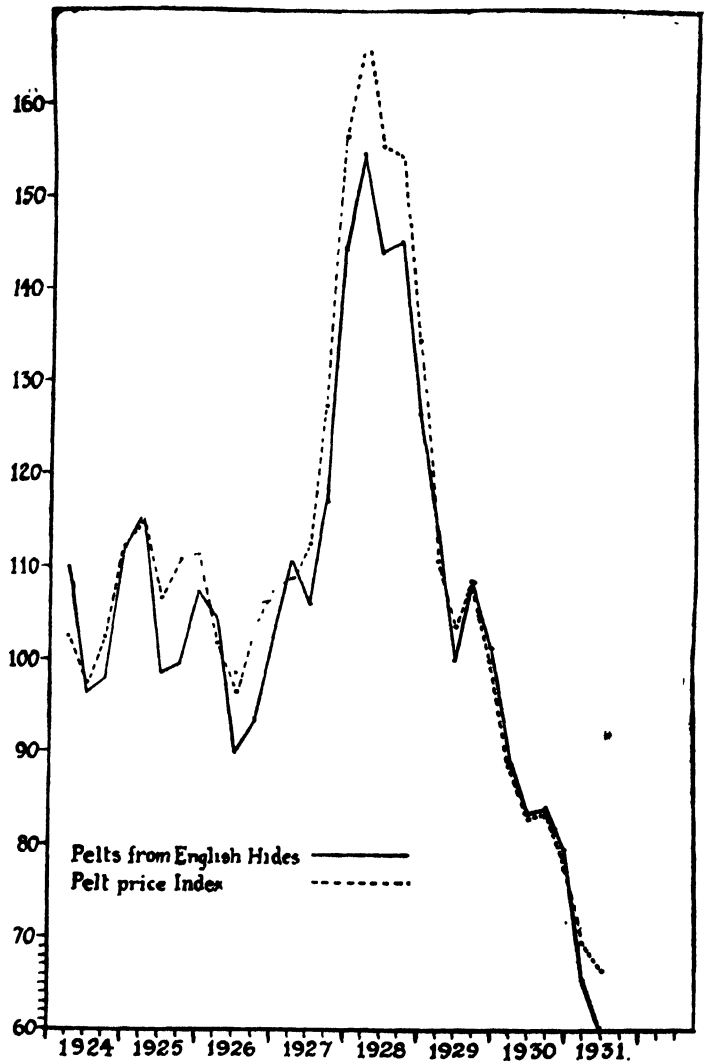
Prices 1924-1931.

Taking the course of general hide prices from 1900 to 1930 in Diagram I, it is clear that changes in prices occur quite apart from the movements of meat prices. Hide prices correspond only roughly to the movement in the general level of prices, the two periods 1902-10 and 1920-31 being particularly noticeable for

movements in hide prices which were much more definite than although following the same trend as the index of general prices. Of greater interest to the livestock producer, however, is the probable future course of the index of prices and how this is going to affect cattle and meat values. In Diagram III the

DIAGRAM III.

Hide prices, 1924-1931.

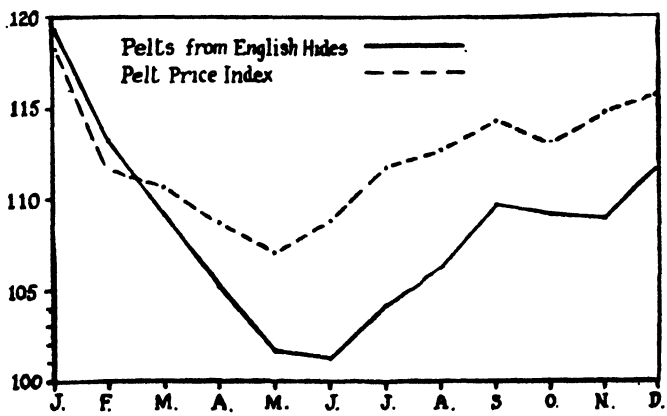


monthly variations in prices of English hides, converted to indices on the basis of average 1928 = 100, are shown from 1924 to the present time. If the trend of these indices is scrutinized there

will be found a definite seasonal variation in prices, tending to fall in the early and rise in the later months of the year. This seasonal fluctuation, however, is partly due to variation in the quality of the hides. To arrive at an equitable basis of price quotation, eliminating the effect of varying quality on prices, the United Tanners Federation have devised a Pelt Price Index, which allows for variations in quality and eliminates as far as possible its effect on price quotations. The Pelt Price Index, therefore, shows the real fluctuations in prices for a commodity of standard quality. The Pelt Price Index is presented in Diagram III and the net influence of varying quality of the hide can be estimated by comparing the two curves, one of market price variations of English hides and the other of actual variation in price for a standard product. The actual seasonality of prices based on these two curves is given in Diagram IV. Seasonality as measured through the Pelt Price Index represents the actual fluctuations in prices according to season, while seasonality as calculated on actual prices is a complex of price fluctuations and quality variation. The line of the Pelt Price Index, as illustrated in Diagram IV, shows a fairly clear seasonal movement in prices, tending to fall regularly in the spring months.

DIAGRAM IV.

Seasonal trend of hide prices, 1924-1931.



From September, 1928, hide prices in the English markets have fallen rapidly (Diagram III) from about 10½d. per lb. for first quality ox hides to about 4½d. or 5d. in August, 1931. The actual course of hide prices since 1924, compared with prices of fat cattle (average first and second quality Shorthorns) can be seen in the following table :—

Average prices of hides and fat cattle, and general prices indices, 1925-1931.

		Ox hides, first quality.*	*Fat Cattle.†*	*Index of Prices of all farm products,†* 1911-13=100.	*Index general level of prices,‡* 1913=100.
		Pence per lb.	Per live cwt. s. d.		
	1925	8.5	56 0	159	159.1
	1926	7.9	52 1	151	148.1
	1927	8.0	47 1	144	141.6
	1928	9.6	51 4	147	140.3
	1929	6.9	49 1	144	136.5
	1930	6.2	48 9	134	119.5
Jan.	1931	5.6	47 0	130	106.9
Mar.	1931	4.8	46 0	128	105.9
June	1931	4.6	48 10	123	103.2
Sept.	1931	5.3	44 6	120	99.2

* Prices published weekly by the *Economist*.
† Ministry of Agriculture Annual Statistics and Weekly Market Report.
‡ Board of Trade Index Number.

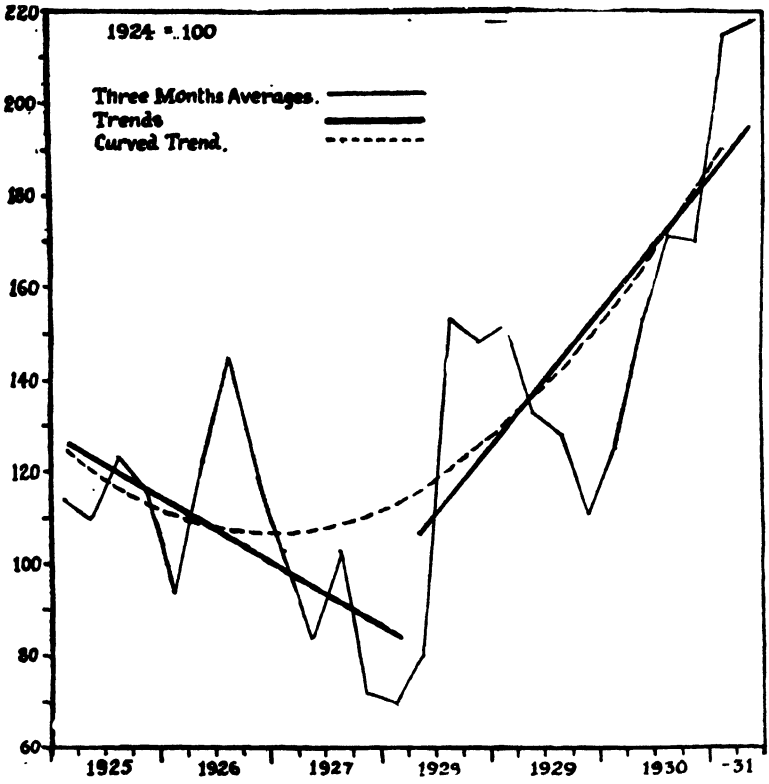
Prices of hides fell 35-40 per cent. in the period 1924-31, and this is almost exactly the same decrease as shown by the general level of prices according to the Board of Trade Index number. The general level of prices, however, has dropped almost continuously from 1925 while prices of hides reached a high peak in 1928 and dropped to about one-half the value in a period of less than three years. Prices of farm products show a gradual decline which was not quite as severe as that in prices of all commodities. But cattle prices, although on the whole showing some decline after 1925, do not show the same rapid fall in the period 1928-31 as has been the case with hides.

The causes of the severe depression in hide prices of recent years are partly to be explained by the fact that by-products are easily subject to severe fluctuations in prices. But the underlying causes in this particular industry are closely bound up with the present general depression in industrial activity. Consumption of boots and shoes has been curtailed and indeed demand for all leather products has been slow. The supply of hides, however, has not responded to a decrease in demand, because the numbers of cattle slaughtered remain fairly constant, and prices of hides naturally tumble to low levels as a result. The state of the leather industry is illustrated in Diagram V, where the percentage of insured unemployed is shown to have decreased from 1925 to the summer of 1928. Unemployment was heavy for the latter half of 1928 but conditions improved slightly towards the close

of 1929. With increasing depression in 1930 employment decreased and the unemployment figure for the leather trades in the second quarter of 1931 was over 20 per cent. The Indices of industrial activity in the leather trade, although the figures are

DIAGRAM V.

Unemployment in leather trades, 1925-1931.



not available for the whole period, indicate a decline in volume of production in recent years from the level of 1928. But although hide values have been and are still very low, the leather trades had to curtail production, and the inevitable break in confidence followed, which affected all the subsidiary industries back to the farmer as primary producer.

Relation between values of Hides and Cattle.

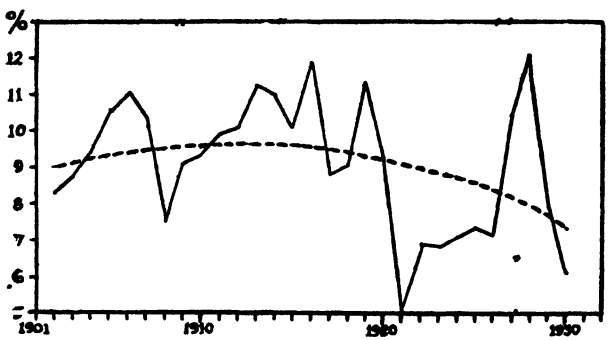
As an approximate guide it is usually estimated that the value of the hide is about 10-12 per cent. of the value of the live fat animal. This figure naturally is subject to considerable variation according to prices of hides and prices of meat, and prices

of these two products sometimes move in opposite directions. In any case, a severe depreciation in the price of hides, the principal by-product of the meat industry, has the effect of lowering somewhat the quotations for the live animals from the farm. Likewise, the meat wholesaler or butcher reduces his valuation of a beast which possesses a badly warbled hide or a hide which for one reason or another is not of first quality.

Although the division of interest between the producer who is selling and the butcher who is buying a live beast may tend to obscure the importance of hide values, whether determined by general supply and demand in hide markets or by the condition or quality in individual hides, it is clear that differences may arise of the order of 5 to 7 per cent. of the total value of the beast. But taking the whole trade in native hides, which represents in value every year, even at present prices, between four and five million pounds, a reduction in prices due to poor quality is of considerable importance to farmers, beef producers, and slaughter establishments. The ratio of hide value to total value of live cattle is shown for the past thirty years in Diagram VI.[5]

DIAGRAM VI.[5]

Ratio of hide to value of beast.



Unfortunately there is little hope for any immediate recovery in hide values, and as long as the present low industrial activity in the leather trades continues and present business conditions remain, the position with hides will tend to become steadily worse as excess supplies from slaughter at present levels of demand continue to accumulate.

[5] Diagram 6 does not in fact show the whole position, for when the value of hides is low, this tends to reduce the price of fat cattle, and *vice versa*, so that the total effects of changes in values of hides are slightly greater than indicated by the Diagram.

The line indicating percentage values in individual years shows variations from 5 per cent. in 1921 to about 12 per cent. in 1916 and 1928. From 1908 to 1918 the proportion of the value of the hide to the total value of the live beast was rising, then with some fluctuations it rose to a high point in 1916, and there were very marked declines 1919-21 and 1929-30. The decline shown for 1930 continued into 1931.

Liveweight prices of fat cattle bear a close relation to the estimated market value of the meat in the carcase, and the value of the hides and other inedible and edible offals; but the two chief products are the meat and the hide. If the price of fat cattle is converted to a dead-weight basis (on the recognised standard of four-sevenths) it will be found that the apparent price of meat will be higher than the price of equivalent quantities and qualities purchased as dressed carcases in the wholesale meat markets. This margin of difference between the apparent price of meat purchased in the live animal (at the liveweight price) and the price of meat purchased as dressed is very largely due to the value and price of the hide, but some other factors are concerned in its determination. In general, this margin is determined by the net difference between (*a*) the expected value of the hide and other offals, and (*b*) the cost of transport of beast to slaughter-house, cost of slaughtering and dressing, and cost of transport of meat to the wholesale market. Occasionally there are slight fluctuations in prices of dressed meat which have no connection with these values and costs, because they arise from conditions of demand and supply in the markets for dressed meat, but over considerable periods of time these fluctuations up or down tend to balance each other. The costs or charges mentioned are fairly stable for considerable periods in any given market area, and in any case changes in them are not determined by conditions in the markets for live cattle, meat, or hides. And in general the value of the offals may be indicated by adding to the actual costs of transport, slaughter, etc., the margin that exists between the price of dressed meat and the calculated dead weight price of meat in the live beast. The margin between prices of dressed beef in wholesale meat markets and the estimated price of meat in live animals as sold at liveweight prices over whole years is found to be :—

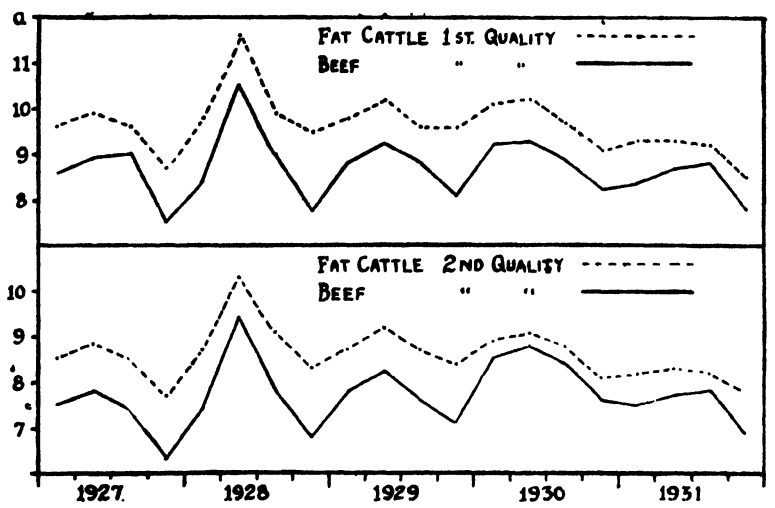
Margin between dead-weight prices of fat cattle and prices of dressed beef.

	First quality beef and live cattle. Per 8 lb.	*Second quality beef and live cattle. Per 8 lb.*
	Pence.	Pence.
1927	7.76	8.56
1928	10.40	9.44
1929	8.48	8.80
1930	7.00	8.36
1931	5.60	4.64

This difference is thus shown to be high when the price of hides is high, and *vice versa*, as would be expected from the fact that the hide is the chief product other than meat. The position is further illustrated below in Diagram VII, which shows the average margin in the case of both first and second quality beef and fat cattle for three-monthly periods over five years. Here it is seen that the margin tends to be relatively wide during the autumn period when hides tend to realise the higher prices.

DIAGRAM VII.

Margin of difference in fat cattle and beef prices, 1927-1931.



It is clear from these figures and Diagram VII that the effect of a decline in the value of offals, and especially of hides, is reflected in the liveweight prices of cattle, and so far as hides are concerned the effect is the same whether it arises from general conditions of demand and supply in the hide markets or from deterioration of quality in individual hides. Had hide prices

remained at the level reached in 1928 the following approximate amounts would, on the average, have been added to the prices of fat cattle sold in recent years :—

1929 — 14s. 6d.		First half 1931 — 25s. 0d.	
1930 — 18s. 6d.		Second half 1931 — 23s. 9d.	

It is no exaggeration to say that conditions in Wales with regard to the care of hides both by the farmer and the butcher are as bad if not worse than in any part of this country. Killings of cattle are on a comparatively small scale, undertaken in scattered units with little or no control, and there is little realisation of the importance of high quality in skins. Killing on a small scale certainly does not offer the same opportunities for uniform grading and handling as a central abattoir operating on a large scale, but there is little or no excuse for poor and inefficient flaying, which in many cases spoils a good quality hide for any but the most unremunerative sections of the trade. The same is true of the warble trouble. There is an attempt at the moment to give publicity to the ravages of this pest and the damage that arises. It is only to be hoped that farmers will take the necessary step to eradicate it completely in the next few years. It is in their own interest to do so, and in the interest of a great national industry.

CHANGES IN THE SHEEP POPULATION OF WALES.

By J. Glynne Williams, B.Sc., M.S.,
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I. General changes in Flocks.

Changes in the sheep population of a country may be studied from a variety of different aspects. There may be general long period trends either towards increase or decrease together with short period fluctuations or deviations from these general trends. Or, the total population may be divided into the different classes of sheep and the general long period trends and the minor or major fluctuations from these trends may be studied. Within these types it is found possible to have a general tendency to decrease in one class of stock, *e.g.*, breeding ewes, lambs, or store sheep, whereas the other classes of stock may be increasing and the net result reflected in the total population may be either an increase or a decrease according to the magnitude of the relative changes. It is further possible to trace the relationship between

the changes in one of these classes and the changes in another class in the following year, and with a knowledge of this to estimate the influence of a change in one type of stock on the numbers of another but different type the following year. But the changes in some of the different areas of the country may be entirely different from those in the country as a whole, as the aggregate figures conceal the more localised movements. This study is an attempt to detail the changes in the sheep population of the country in their many and varied aspects, and at the same time to offer certain practical suggestions as to causes.

In 1867, for which year official statistics were first made available, the total number of sheep in Wales (including Monmouth) was 2,410,000. The tendency has been for numbers to increase, but there have been several serious checks due to a variety of causes. The first important decline in sheep numbers occurred in 1874 and continued with only a slight check in 1878 until 1881. From the low figure of 2,584,000 in this year a steady increase is recorded, checked only in the year 1886, and the four years 1892-3-4-5, until 1909, when the total population recorded was nearly 4,054,000. During this period of twenty-eight years the increase in sheep was 1,469,000, or slightly more than the average figure of 52,400 per year. Stated in another way, the sheep population increased over 56 per cent. during a period of twenty-eight years. Since 1909 the total sheep population has been very variable, and there does not appear to be any general trend. The decreases in the years 1910-3 were more than compensated by increases in the years 1914-6. But the heavy falls in the four years commencing 1917 reduced the total population to the lowest figure recorded since 1895. Six years of consistent increases followed, when in 1927 the highest recorded total population, 4,282,000, was returned. Small decreases were shown in 1928 and 1929, but the return in 1930 showed a small increase, the total population again being over 4,000,000. The general trend of sheep population was to increase fairly rapidly until 1909 and although the total figures have at times been higher than in this year the marked tendency to increase has been severely checked. Whilst it may be hazardous to forecast, nevertheless the general trend suggests that any continued and marked increase over a total population of 4,000,000 is most unlikely.

A glance at the cattle population statistics[1] shows a similar tendency to increase, but in this case the peak figure was reached in 1916, after which there appears a tendency to fall. The

[1] Ashby and Lewis. Cattle Population and Supply. This *Journal*, Vol. V, 1929.

figures for 1930 show an increase of approximately 85 per cent. over the figures for 1867, whereas the total increase in sheep was approximately 70 per cent.

The increase in sheep population was, however, by no means uniform throughout the country, as shown in the Table below :—

Sheep population of each county in Wales for 1867 and 1930 and the percentage increase.

	1867.	1930.	*Percentage increase.*
Anglesey ...	49,702	143,678	189.0
Brecon ...	300,107	497,920	66.0
Cardigan ...	138,028	305,716	121.5
Carmarthen ...	158,750	302,163	90.3
Caernarvon ...	164,180	297,605	81.3
Denbigh ...	212,398	158,644	115.9
Flint ...	64,580	130,602	100.7
Glamorgan ...	229,547	324,259	41.2
Merioneth ...	293,697	129,879	46.4
Montgomery ...	277,059	515,111	85.9
Pembroke ...	95,166	153,857	61.6
Radnor ...	248,947	321,662	31.9
Monmouth ...	182,985	221,314	20.9
		Average ...	70.2

It is difficult to explain the marked variation in increases of sheep between the various counties. It is generally known that there has been a marked increase in the livestock population of the country and a similar table for cattle increases also shows considerable variation and little or no consistency in the counties.

Cattle population of each county in Wales for 1867 and 1930 and the percentage increase.

	1867.	1930.	*Percentage increase.*
Anglesey ...	33,885	49,161	45.3
Brecon ...	31,186	38,138	22.3
Cardigan ...	18,551	64,959	33.8
Carmarthen ...	87,829	115,287	31.3
Caernarvon ...	42,414	49,324	16.3
Denbigh ...	46,438	74,486	60.4
Flint ...	21,153	43,207	104.2
Glamorgan ...	45,099	57,698	27.9
Merioneth ...	33,284	34,193	2.4
Montgomery ...	59,510	78,436	31.8
Pembroke ...	67,083	96,879	44.4
Radnor ...	28,156	33,527	19.1
Monmouth ...	35,168	49,455	40.6
		Average ...	35.4

On classifying the counties it is found that three in North Wales—Anglesey, Denbigh and Flint—each had increases in both types of livestock above the average. Increases of sheep above the average but increases of cattle less than the average are shown for the counties of Cardigan, Carmarthen, Caernarvon, and Montgomery. Thus, of the six North Wales counties, five show increases of sheep above the average. Of the counties showing increases of sheep less than the average, Pembroke and Monmouth show increases of cattle above the average, and the remaining counties of Brecon, Glamorgan, Merioneth and Radnor show increases in both classes of livestock, but in each case below the average. In the latter group, with the exception of the county of Glamorgan, the limiting factor in increase of cattle population is probably the area of land over 1,000 feet above sea level, Brecon having 57.3 per cent., Radnor 55.1 per cent. and Merioneth 47.4 per cent. The county of Glamorgan has only 14.2 per cent. of its total area above 1,000 feet. Of the typically lowland counties Anglesey, with the whole of its area below 1,000 feet, in fact 99.9 per cent. below 500 feet, and Flint with only 3.7 per cent. above 1,000 feet, show increases in cattle and sheep; the former 189 per cent. increase in sheep and 45.8 per cent. in cattle, whilst the latter shows increases of 102.2 per cent. in sheep and 104.2 per cent. in cattle. Pembroke, another typically lowland county with only 1.6 per cent. of its total area above 1,000 feet, shows an increase of sheep of 61.6 per cent. or nearly 9 per cent. below the average for the country, and an increase of cattle of 44.4 per cent. or 8 per cent. above the average.

	Percentage of total area over 1000 feet.	*Number of sheep per 100 head of cattle.*	
		1867.	1980.
Anglesey ...	—	147	292
Cardigan ...	22.7	284	471
Carmarthen ...	10.2	181	262
Flint ...	3.7	305	302
Glamorgan ...	14.2	509	562
Pembroke ...	1.6	142	159
Monmouth ...	15.8	520	448

The counties of Pembroke and Monmouth are the only two showing an increase in cattle above the average together with an increase in sheep below the average. The failure of Monmouth to increase its sheep relative to other counties may be due to the much greater relative density of sheep to cattle within the county in 1867. The Table above shows the number of sheep of all

classes per 100 head of cattle of all kinds within the counties with less than 25 per cent. of the total area above 1,000 feet.

Thus the county of Monmouth was much more heavily stocked with sheep relative to cattle in 1867—though by 1930 Glamorgan and Cardigan had increased their sheep relative to cattle more than this county. The Table is interesting as it shows a decrease in the number of sheep relative to cattle in the county of Monmouth, a stable relationship in Flint, an almost stationary relationship in Pembroke, increases in Glamorgan and Carmarthen, together with large increases in Anglesey and Cardigan.

It is interesting to note that the failure to increase sheep numbers after 1909 is localised in the four South Wales counties of Monmouth, Glamorgan, Carmarthen and Pembroke, to which group may also be added Brecon, although this latter county did actually attain a higher sheep population in 1927 than in any pre-war year. The following Table shows the changes in as concise a manner as possible.

Sheep population.

County.	1867.	*Year of lowest population and number.*		*Year of highest population and number.*			
				Up to 1916.		*Post-war.*	
		Year.	*No.*	*Year.*	*No.*	*Year.*	*No.*
Monmouth	182,985	1881	117,402	1909	259,224	1927	222,452
Glamorgan	229,547	1880	253,821	1906	349,672	1930	324,259
Pembroke	95,166	1881	85,738	1909	164,188	1930	153,857
Carmarthen	158,750	1881	198,261	1916	316,480	1927	308,631
Brecon	300,107	1867	300,107	1907	534,819	1927	539,312

At the other extreme there are the counties of Denbigh and Anglesey. The former had a population of 212,398 in 1867, this being the lowest figure ever recorded, and rising to a peak in 1891 of 331,819, then attaining another peak in 1909 of 421,531, and after a slight check increasing to 441,016 in 1916, showing a heavy fall in the three following years, but rising rapidly from 1920 until 1927, when the total figure returned was 482,448. Anglesey had a population of 49,702 in 1867, and showed similar peaks in its general trend—of 76,898 in 1891; 118,756 in 1908; 130,717 in 1916, rising to a maximum total population of 145,879 in 1927. The remaining counties each show small post-war increases over any total previously recorded. The county of Flint is, however, unique in that the 1930 total sheep population was the highest ever recorded.

The peaks mentioned in the discussion above suggest the main deviations from the general trend in the total sheep population of the country. From 1867 to 1874 there was a marked increase, checked only in 1869-71. But from 1875 there was a fall, checked only in 1878, until 1881. This movement is shown in the county figures with the exception of Flint, which showed increases in 1877-9; Cardigan, which maintained previous numbers until 1880; and Merioneth. Merioneth and Cardigan are unique in that they maintained their populations until 1885. It is also interesting to note that these counties, together with Denbigh and Caernarvon, did not suffer so heavily in the fall as the other counties of Wales. An explanation of the heavy fall in 1880 and 1881 must be found in circumstances affecting mainly the nine remaining counties. These years were generally characterised by periods of cold and wet weather, disastrous outbreaks of liver-rot inflicted enormous losses on sheep farmers, and this fact probably accounts for the decreases. It is, however, interesting to note the counties which appear to have been spared the heavy losses, namely, Flint, Cardigan and Merioneth, though it is difficult to offer any explanation of the apparently lighter incidence of disease in these areas. The general increase which set in in 1882 was subject to a heavy check in 1886, but this appears to have been confined to the more mountainous counties. The counties of Flint, Anglesey, Pembroke and Monmouth appear to have avoided losses during this year, whilst Merioneth was a particularly heavy sufferer, the remaining counties suffering only relatively small decreases. It is probable that this was due in the case of the county of Merioneth to a particularly bad lambing season, as the decrease in sheep over one year old was only 11 per cent. of the 1885 figure, whereas the decrease in sheep under one year old was 39 per cent.

From 1887 to 1891 there was a fairly rapid increase, but the totals fell somewhat in the years 1892-5. This fall is shown in the figures for each county in Wales and was probably due to the fall in prices. Sheep prices had been well maintained up to 1890, although prices of fat cattle had been falling since 1886. At this time the live stock industry was feeling the effects of the development of the importation of meat into this country, which commenced in 1877 but assumed menacing proportions about 1890. The agricultural industry in general was suffering from a depression and considerable readjustment in production was being undertaken. The marked importance of sheep in this readjustment is shown by the increase in sheep population from 1895 to 1909. Cattle did not share in this increase as the peak

figure of 809,788 in 1891 was not passed during the remainder of the century, although the 1900 figure of 808,185 closely approached it; in fact it was not passed until 1915, when the total reached 887,204. The increase in sheep 1895 to 1909 was, however, by no means uniform in all counties throughout the period. The three lowland counties, Pembroke, Flint and Anglesey, showed increases from 1895 to 1905, but Pembroke showed a check in 1899, and Anglesey in 1901. Then from 1905 to 1909 these three counties showed marked increases, whereas the remaining counties showed a general tendency to increase steadily, although a check occurred in Brecon, Radnor, Glamorgan and Carmarthen in 1907.

During 1911 it is reported that store livestock was almost unsaleable, and the natural result was a check in production. Incidentally, whilst this weakness of markets persisted, the prices for fat sheep were relatively good, and this increased slaughter. This is clearly shown in the marked decreases in sheep population in the lowland counties.

It is difficult to explain fully the causes of these changes owing to their complexity. Disease was the cause of the great fall from 1879 to 1881, but the effects of disease appear to have diminished as knowledge and skill in management developed in the passing years and a repetition of the heavy effect is now extremely unlikely owing to the special increase of knowledge in the past few years. But the general increase in sheep appears to be due to general factors affecting the agriculture of the country which are reflected in the marked development of livestock production.

II. Sheep and other Livestock.

The general trend of increase in the total sheep population and increase in sheep production in Wales as a whole has been due to a number of causes. On the whole sheep did not supplant cattle or any other kind of pastured stock. There was an increase in numbers of horses up to the end of the war period, although there has since been some decline. As previously shown, the total numbers of cattle have increased. While it is difficult to provide a strictly accurate and reliable index of the total quantity of livestock of all kinds and classes on farms when the numbers of different kinds and classes and their proportions are changing, it is possible to provide an indicative statement of quantities. Converting all classes of livestock into " animal units " on a " cow " basis, the following Table shows the number of " animal units " on Welsh farms at different periods.

The " unit " is an estimate of relative food requirements of horses, sheep, cattle and pigs, and thus the increase in numbers shown indicates also an increase in food requirements, in pasturage and others forms, of all livestock on Welsh farms.

Livestock on Welsh farms in animal (cow) units, 1867–1929.*

	Total number. (000).	*Percentage change from base.*	*Percentage change from previous period.*
1867-69	926	100	0
1870-74	985	106.4	6.4
1875-79	1,009	109.0	2.4
1880-84	997	107.6	— 1.2
1885-89	1,047	113.1	5.0
1890-94	1,122	121.2	7.1
1895-99	1,105	119.3	— 1.5
1900-04	1,139	123.0	3.1
1905-09	1,172	126.6	3.0
1910-14	1,156	124.9	1.3
1915-19	1,194	129.0	3.3
1920-24	1,130	122.1	— 5.3
1924-29	1,160	125.3	2.6

* This and the following estimates of " units " prepared by W. J. B. Hopkinson, B.A., in the Department of Agricultural Economics, Aberystwyth.

Thus, taking all classes of livestock (except poultry), there has been a net increase on the " cow " unit basis of about 25 per cent. in the last sixty years. This general increase has been associated with some changes in area of land used for agricultural and pastoral purposes; a rise in total cultivated area (arable and improved pasture) from 1867 to 1891, and a fall since that year which was slight until 1917 but greater since 1920; and a decline in arable itself from 1870 to 1915, when an expansion occurred under the special circumstances of the war, and a more marked decline since 1920. But these changes in the total cultivated area and in the distribution between arable and pasture are small when compared with the changes in the numbers of livestock carried and in their food requirements. The first break in the tendency towards general increase in livestock is shown in 1880-4, and was entirely due to the fall in numbers of sheep mainly as a result of disease. The second break, in 1895-9, was due partly to decline in cattle as well as to decline in sheep, and was largely the result of low prices at the period. While in the third break, 1910-4, the decline was common to all classes of livestock. It appears to have been caused to some extent by the dry season of 1911, and by heavy selling of stock in some of these years. The last break,

that of 1920-4, was due to decline in sheep and cattle, caused by the very heavy selling from 1921 to 1928.[2]

The most striking fact is that of the continuation of the general increase up to the end of the war period, in spite of some set-backs, and the return to the tendency towards increase since 1925. The general increase in amounts of livestock carried has required an equivalent increase in food supplies, or might be said to have been due to an increase in these supplies. It is not entirely due, however, to a decrease in arable area and in production of crops for sale, and the setting free of arable land for pastoral use. The amount of land changed from arable to pasture does not, in fact, represent a net gain of this area for livestock production, for much of grain and straw grown on the arable, which has disappeared, had been used for stock food.

The increase in food supplies for the increased livestock has been obtained by (1) increased yields of arable crops, (2) improvement of pasture (more particularly by manuring) and increased yields of hay;[3] and by (3) increasing purchases of concentrated feedstuffs which were being offered in greater variety and quantities, and for long periods at relatively low prices. Yields of arable crops tended to rise from 1885, when they were first recorded, to about 1910, but changes in yields are illustrated below.

Average yield per acre of oats, hay from permanent pasture, and hay from clover, etc.

	Oats.	*Hay from permanent pasture.*	*Hay from clover, etc.*
	Bushels.	Cwt.	Cwt.
1885-89	31.64	18.66	19.34
1890-94	33.52	17.85	22.24
1895-99	32.88	18.13	24.37
1900-04	33.25	18.64	24.08
1905-09	35.76	20.33	25.43
1910-14	34.76	20.17	25.78
1915-19	35.46	19.12	24.78
1920-24	28.72	19.47	24.33
1925-29	36.45	18.03	23.58

It is quite possible, however, that the most important factor in the increase in general food supplies for livestock has been the increase in purchases of concentrated feeds at relatively favourable prices.

[2] For changes in numbers and use of horses, see Davies, "Horse Labour on Welsh Farms". This *Journal*, Vol. VI, 1930.

[3] Since 1918, by smaller sales of hay.

In certain individual counties like Anglesey and Flint, where there have been very marked increases in numbers of livestock (p. 54 above) and more than the average loss of arable land (Anglesey 1867 = 100, 1930 = 68.7; and Flint 1867 = 100, 1930 = 42.2) the livestock have to a more appreciable extent taken the place of crops previously grown for sale. But considering the whole of the Principality as one area, the situation is as stated above.

The increases in yields of grain crops and of hay in some periods, and the continued increase in purchases of concentrated feeds would not directly affect production of sheep so much as production of cattle. But they affected sheep production to some extent and they set free supplies, especially pastures, for sheep. From year to year the horses, cattle and sheep together balance with the pasture supplies of the farms, and roughly with the hay supplies; although up to 1918 there were fairly considerable sales of hay. Some grain is sold, but over all the farms purchases of concentrated feed are, and have been since at least 1905, far greater than the sales. But in a general way, horses, cattle, sheep and pigs balance the food supplies of the farms—including pastures, hay, roots, home-grown grain retained, with some straw, and purchased concentrates. The nature of the food supplies, and proportions from each source, have been changing to some extent, but the total supply has been increasing. On

Proportion of animal (cow) units in each class, 1867–1929.

	Horses.	*Cattle.*	*Sheep and Lambs.*	*Pigs.*	*Total.*
1867-69	14.2	54.6	28.7	2.5	100
1870-74	18.1	54.0	30.2	2.7	100
1875-79	14.0	53.7	29.8	2.5	100
1880-84	15.0	55.8	26.7	2.5	100
1885-89	14.5	56.3	26.7	2.5	100
1890-94	14.3	54.6	28.7	2.4	100
1895-99	15.2	52.5	29.6	2.7	100
1900-04	14.9	51.9	30.9	2.3	100
1905-09	15.0	51.1	31.6	2.3	100
1910-14	15.1	51.6	31.1	2.2	100
1915-19	14.6	53.2	30.4	1.8	100
1920-24	15.1	53.7	29.0	2.2	100
1925-29	11.8	53.6	32.6	2.0	100
Average	14.8	53.5	29.9	2.8	100

the whole it would be said that the increased food supplies have been obtained to meet the needs of increasing numbers of livestock which offered opportunities of profitable production;

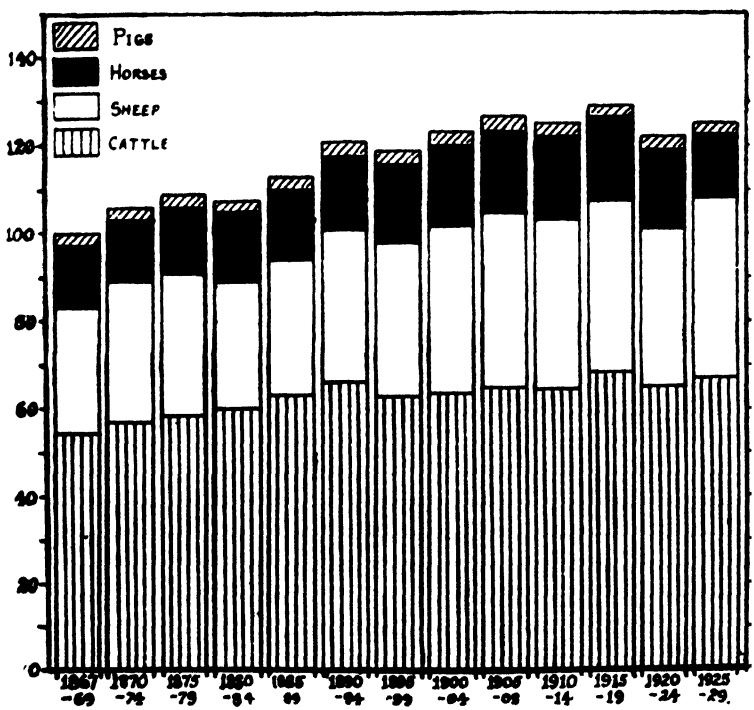
rather than that the stock had been obtained to make use of increasing supplies of feed. And as regards the purchase of concentrates this is obvious.

This being the case, it is both interesting and important to note that according to the estimate of livestock units the relation of sheep to cattle as food consumers on the farms has been fairly constant over the last sixty years.

As the maintenance of horses is not a direct profit enterprise to such extent, the causes of changes in relation of horses to other classes of livestock have to be looked for in the conditions under which the work of the farms is done.[4] Pigs represent a very small proportion of the total stock, and have almost negligible requirements as regards pasture and hay.

DIAGRAM I.

Numbers of live stock units in Wales ("cow" basis), 1867-1930.



The relationship between cattle and sheep is very striking. Except in the period 1880-9, and to a less extent 1900-14, it could not be said that either cattle or sheep was more profitable

[4] Davies, *op. cit.*

than the other to a degree sufficient to stimulate the diversion of more food supplies from one kind of stock to the other. And in the earlier period the effect of disease on the flocks was probably the dominant factor in the change in relationship.

If the " animal units " test of relations between numbers of stock of each kind, and their use of feed, is not accepted it will be seen that when actual numbers of each kind of stock are compared there is little difference in the relation of sheep and cattle from one period to another.

Proportion of each kind of stock to 1,000 total number of all livestock.

	Horses.	*Cattle.*	*Sheep and Lambs.*	*Pigs.*	*Total.*
1867-69	35.6	166.0	740.7	57.7	1,000
1870-74	31.6	162.2	748.8	57.4	1,000
1875-79	34.2	163.0	748.0	54.8	1,000
1880-84	39.3	184.5	716.6	59.6	1,000
1885-89	37.7	183.5	719.5	59.3	1,000
1890-94	35.4	171.8	738.4	54.4	1,000
1895-99	36.3	164.3	742.3	57.1	1,000
1900-04	34.6	159.6	755.7	50.1	1,000
1905-09	34.4	154.6	764.8	46.2	1,000
1910-14	34.5	156.0	764.1	45.4	1,000
1915-19	34.5	168.4	758.1	39.0	1,000
1920-24	36.6	168.8	746.7	47.9	1,000
1925-29	26.8	156.8	776.4	41.0	1,000
Average	34.7	166.0	747.8	51.5	1,000

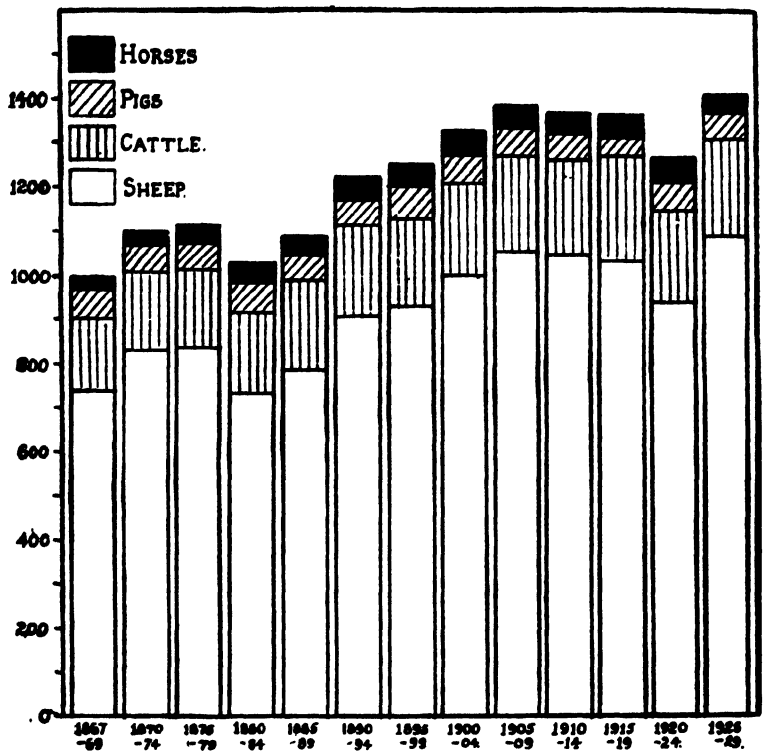
The proportion of sheep amongst the total livestock of the farms is thus seen to have been remarkably steady, except during the period 1880-9, after the disastrous seasons at the beginning of that decade.

As noted before, there are differences between conditions in one county and another, and only the general position over the whole of the Principality is dealt with here. Moreover, these crude figures for stock of each kind obliterate changes in the classes of each kind of stock such as the increase in dairy cows amongst the cattle, or the decrease in the older stores amongst the sheep. But there is still nothing to indicate any radical change in the general position and importance of sheep on the farms. All that can be said is that conditions have been favourable to an increase in livestock production, and that sheep and cattle have increased together; and having regard to the conditions of the utilisation of pastures and general food supplies, it would hardly be too much to say that they have increased jointly.

It may be suggested, however, that the increase in sheep population in Wales is only a part of a general movement towards increase of mutton and lamb production in pastoral areas which is to be seen in other parts of Great Britain, and which is accom-

DIAGRAM II.

Numbers of live stock in Wales, 1867-1929.



panied by a reduction of flocks in arable areas. Doubtless this is the case, and the diminution of supplies of sheep and mutton from arable areas has to some extent opened up markets for the increasing supplies from Welsh farms. But such an increase as has occurred might have been obtained at the expense of production of cattle; or to some extent, possibly, by a still greater diminution of the arable area of Wales than is found. In general, conditions in Wales have been favourable to an increase in livestock production, and the chief kinds, cattle and sheep together, have shown a considerable increase; and in order to obtain this increase farmers have obtained increased supplies of feedstuffs in various ways. It is certainly possible, and it appears probable, that production of sheep in Wales has increased a little more than

that of cattle, and it may be inferred that sheep have been a little more profitable than cattle in recent years. But in the process of increasing, it has been necessary to make considerable changes in the constitution of the flocks and the class of products, and these changes require some analysis.

III. Changes in Classes of Sheep.

The chief changes in the constitution of the total sheep flock are (1) a reduction in the number of store sheep over one year old, with a consequent reduction of the age of slaughter of mature mutton; (2) an increase in fattening and slaughter of young lamb, especially in some lowland counties, and (3) a consequent rise in the proportion of breeding sheep (ewes and rams) in the flocks.

In studying the changes in the different classes of sheep, some estimates have been necessary because of the simple forms of the records for the early years. The actual recorded numbers of sheep, and the complete estimates, are given in the Appendix. Although there must be a small element of uncertainty about the estimates, it is clear that changes of very considerable importance have occurred. The number of rams and ram lambs is necessarily closely related to the number of breeding ewes, but there is no absolute relationship between the two classes because an increase or a decrease in the number of small flocks will tend to bring similar changes in number of rams required, even though the total number of ewes in the country remains at the same level. Allowing for differences in lamb " drop " or yield in the different seasons, there will be a close relationship between actual numbers of lambs reared and the number of ewes, but as the tendency to early slaughter rises, more lambs born after January are killed before June, and thus are not recorded in the June *Statistics*. But the change in the number and proportion of sheep over one year old kept on farms is of an absolute character.

Prior to 1882 it is estimated that the number of other sheep over one year old was about equal to the number of ewes, but after this date the breeding ewes increased far more rapidly than the other sheep over one year old. The marked decline in the older store sheep did not set in until 1898, although there was a general tendency to decrease from 1875. Between the latter year and 1930 there was a decrease of nearly 56 per cent. This fall more or less coincides with the introduction of frozen mutton and lamb into this country. Assuming the fall from 1875 to 1885 to be due to the same causes as the fall in other types of sheep, the failure to increase coincides with the year in which imports of

mutton and lamb just passed the total of one million carcases. In 1892 there was a slight check in the rapid increase of these imports, but the increase again continued from 1898 until 1900. It is interesting to note that these two checks in imports in 1892 and 1900 are reflected in the number of wethers in the country. Other factors were operating as well, for in spite of the increase in imports from 1900 to 1912 of over six million carcases the decrease in this type of sheep was by no means marked. From 1882 to 1900 wool prices had shown a general tendency to fall, but in the latter year recovery set in. Prices of wethers were well maintained throughout the period, and continued more or less stable until the outbreak of war. But wool prices showed the recovery mentioned, and it appears that this was responsible for the marked check in the fall. The heavy decline in this class of sheep in 1916 coincided with a similar decline in breeding ewes, and thus the cause was general and not specifically affecting store sheep over one year old. Other factors contributing to the decline in this class of sheep which cannot be shown statistically are the increase in demand for lamb, and the decrease in demand for wether mutton.[5]

Such factors have tended to reduce considerably the number of wethers maintained on the mountains. The possibility of a continued decrease in this class of sheep depends upon the continuance of operation of these factors. But it may be noted that if there is any marked increase in the value of wool it is possible that this will be reflected in the number of wethers maintained. A further influencing factor is to be found in the management of mountain pastures. With the decline in numbers of wethers and mountain ponies, many experienced hill farmers are saying that there is a marked decline in the carrying capacity of the hill sheep walks. Thus it may be necessary to maintain this type of stock not wholly for direct production purposes but partly as " implements " for the maintenance of pastures. On the other hand modern systems of mountain pasture improvement may be responsible for the renovation of the herbage to the extent that the walks reserved entirely to wethers in the winter owing to climatic and the limited food conditions may be opened to the more remunerative breeding ewes. Thus it is possible that progress in this direction may mean a more or less complete elimina-

[5] It may be noted in passing that in recent years, when the supply of wethers had become small, the seasonal and somewhat irregular presentation of this type of mutton to the market further tended to depress demand. It is suggested that as butchers lost experience of " conditioning " the meat some of them, at least, failed to present it to consumers in its best and most palatable form, and thus again the demand for it was weakened to some extent.

tion of this class of stock. No information is available on the change in age of stores kept. It is more than probable that there has been a marked decrease in the number of 2-3 and 3-4 year old wethers and that the actual number of sheep returned as over one year old consists largely of 1-2 and at most 2-3 year old stock.

The counties in which considerable numbers of the older store sheep are now to be found are Brecon, Merioneth, Montgomery (northern and western areas), Caernarvon, Radnor and Cardigan (northern area), but proportions are highest in Brecon, Merioneth and Radnor. This class of sheep is of little importance in Anglesey, Carmarthen, Flint and Pembroke.

The three other classes of sheep are closely related to each other, and changes in the class of breeding ewes are reflected directly in the other two classes. In the estimated figures the number of breeding ewes from 1867 to 1893 is based upon the number of sheep under one year old. From 1893 onward they are reported separately, and therefore any changes shown are absolute. The Table below gives the statistics of the five counties which show definitely a changing ratio between the number of breeding ewes and lambs on June 4th.

Ratio of lambs to breeding ewes on the 4th June.
(Five year averages).

	Flintshire.	*Anglesey.*	*Pembroke.*	*Mon-mouth.*	*Carmar-then.*	*Wales.*
1895-99	102.3	108.5	117.2	96.1	99.9	90.5
1900-04	101.7	108.6	116.1	96.3	100.8	90.1
1905-09	100.7	99.9	112.5	95.0	98.5	90.3
1910-14	98.0	90.2	107.0	93.7	94.7	92.5
1915-19	99.5	102.9	109.6	94.2	95.2	84.9
1920-24	104.5	100.8	108.8	95.7	95.4	89.7
1925-29	100.7	92.6	102.4	92.0	93.4	88.4
1930	99.1	93.6	104.3	91.5	94.4	88.3

Five year averages are taken in order to eliminate to some extent the effect of markedly good or bad lambing seasons, though it is possible that the effect of a series of such seasons will still be shown. However, it is clearly obvious that the general tendency to a smaller number of lambs to breeding ewes is shown, particularly in the cases of Anglesey and Pembroke. In all counties this decreasing ratio of lambs to ewes was checked slightly during the war period. Whilst information on the fecundity of ewe flocks during the periods is not available, it is hardly likely that it has been reduced in any way, thus the

general conclusion is that these figures reflect the known tendency to increase the sale of early fat lambs. Anglesey and Pembroke, with parts of Denbigh, Carmarthen, Flint and Monmouth, have shown the highest development of fat lamb production.

There is little statistical information on sales of sheep during the latter part of the year except for a very recent period. In January, 1930, a special census of livestock was taken, so that for 1929-30 it is possible to indicate some movements of sheep.

The changes are as follows :—

Sheep population of Wales and Monmouth, 1929–30.

	June 4, 1929.	*January,* 1930.	*June 4,* 1930.
Breeding ewes ...	1,877,364	1,908,000	1,812,038
Rams and ram lambs ..	54,304	61,200	51,900
Under one year ..	1,657,269	666,600	1,561,662
Over one year .	513,468	323,800	519,771
	4,102,405	2,959,600	3,945,366

From these figures it may be estimated that over 900,000 lambs are sold either for slaughter or outside the borders of Wales between June and January. The sales of sheep over one year old in this period appear to be small, for the reduction in numbers between June and January is largely due to transference of shearling store sheep to the breeding flock, and incidentally it may be said that the figures indicate considerable use of ewe lambs for breeding purposes. Between January and June further sales occur, amounting to at least 400,000. Yet it is clear that a considerable number of two year old sheep are on the farms in June. Some 65 per cent. of the store sheep over one year old in January are to be found in Brecon, Merioneth, Montgomery, Caernarvon and Radnor, while less than 8 per cent. are to be found in Anglesey, Carmarthen, Pembroke and Flint.

Since 1920 the number of rams and ram lambs in relation to breeding ewes has been relatively stable at slightly below three per hundred. It was thought that any marked increase in the number of small flocks would have been reflected by a variation in this relationship, but a comparison of the figures for the counties which have most increased their breeding flocks does not show any marked change. These negative results may be explained partly by the fact that the statistics are collected on June 4 annually, when the smaller flockowners would have disposed of some of the rams previously used and would not have purchased rams for the following breeding season.

Conclusion.

During the period under reveiw there has been a marked increase in the number of livestock on Welsh farms. Numerically sheep have contributed largely to this increase, but when a comparison on a " cow " unit basis is made with the increase in the cattle population it appears that both types of livestock have tended to increase proportionally the same. These coincidental increases are both interesting and important, as they emphasise a practical appreciation of the direct inter-relationship between the two types of livestock which has been advocated by grass land experts and which has been recognised by farmers. Cattle and sheep are, within certain limits, non-competitive graziers, and the fullest production of the grazing of the farm is attained by following cattle by sheep. This is further emphasised in the Table (p. 54) which shows the failure of Monmouth to increase its sheep population relative to cattle, whereas other counties succeeded in doing so quite successfully owing to the lower ratios existing in the early years of the period under review.

A further possible explanation of this movement is to be found in the substitutional nature of the final meat products, beef and mutton or lamb, in consumer demand. This would tend to reflect a possible increase in one type, due to demand, to the other type, and these increases and decreases are to be seen more or less moving together. Whatever are the causes it appears obvious that the future of sheep farming is not a matter of mutton, lamb, and wool prices alone, but is really the broader problem of livestock prices and possibilities of obtaining food requirements. As indicated above, the increase in general livestock was connected with a decrease in arable farming, but it does not follow that an increase in arable would have disastrous effects upon sheep farming in this country. Arable farming provides food for the livestock industry, and any decrease in permanent pasture may be compensated partly by an increase in the food from arable land, and if this is mainly used for cattle, it may set free feed for sheep. In some areas there is also a possibility of an increase in arable sheep raising with an increase in arable farming. This type of sheep farming is, however, mainly devoted to the production of 12-15 months' old mutton and a reference to the failure of the Welsh farmer to produce this has been made above. It is hardly likely that the arable farmer will find this market any more profitable, and thus a large development in this direction is not to be anticipated.

APPENDIX.

Numbers of sheep according to classes recorded in Wales and Monmouth, 1867–1930.

Year.	*Ewes for breeding.*	*One year old and above.*	*Rams and ram lambs to be used for service.*	*Other sheep under one year old.*	*Total.*
1867	1,635,883			774,263	2,410,146
1868	1,955,150			918,937	2,874,087
1869	2,004,524			918,290	2,922,814
1870	2,023,788			878,659	2,902,447
1871	2,007,456			877,663	2,885,119
1872	2,089,027			962,604	3,051,631
1873	2,188,044			986,101	3,174,145
1874	2,254,009			1,024,379	3,278,388
1875	2,225,111			938,282	3,163,393
1876	2,133,163			934,433	3,067,596
1877	2,097,475			953,572	3,051,047
1878	2,124,408			998,071	3,122,479
1879	2,121,578			919,383	3,040,961
1880	1,992,401			852,667	2,845,068
1881	1,851,997			732,350	2,584,347
1882	1,833,747			819,009	2,652,756
1883	1,860,190			866,368	2,726,558
1884	1,888,944			932,493	2,821,437
1885	1,960,964			991,650	2,952,614
1886	1,882,051			811,544	2,693,595
1887	1,915,266			1,006,636	2,921,902
1888	1,950,216			966,451	2,916,667
1889	1,992,020			1,028,240	3,020,260
1890	2,107,416			1,162,605	3,270,021
1891	2,278,491			1,181,739	3,460,230
1892	2,302,710			1,129,853	3,432,563
1893	1,220,909	988,402		1,105,174	3,314,485
1894	1,205,594	956,297		1,109,755	3,271,646
1895	1,215,855	938,233		1,049,027	3,203,115
1896	1,301,368	909,658		1,209,763	3,420,789
1897	1,323,887	904,729		1,171,143	3,399,709
1898	1,359,764	869,922		1,252,260	3,481,946
1899	1,424,257	898,770		1,316,516	3,639,543
1900	1,451,437	918,735		1,286,486	3,659,658
1901	1,459,016	888,657		1,307,993	3,655,666
1902	1,469,158	878,970		1,347,673	3,695,801
1903	1,498,202	871,277		1,379,119	3,748,598
1904	1,516,073	869,406		1,342,768	3,728,247
1905	1,534,296	852,767		1,380,857	3,767,920
1906	1,561,923	859,638		1,400,368	3,821,929
1907	1,616,885	860,864		1,466,612	3,943,861
1908	1,653,215	856,673		1,462,681	3,972,569
1909	1,693,567	874,813		1,485,186	4,053,566
1910	1,646,722	855,043		1,485,855	3,987,620
1911	1,613,157	835,412		1,380,823	3,829,892
1912	1,594,073	801,127		1,372,414	3,767,612
1913	1,512,462	802,091		1,285,332	3,599,885
1914	1,609,919	768,273		1,440,070	3,818,262
1915	1,668,594	756,352		1,501,394	3,926,340
1916	1,769,620	815,003		1,532,325	4,116,948
1917	1,727,772	761,671		1,408,455	3,897,898
1918	1,616,046	660,501		1,427,703	3,704,250

Year.	*Ewes for breeding.*	*One year old and above.*	*Rams and ram lambs to be used for service.*	*Other sheep under one year old.*	*Total.*
1919	1,478,458	661,186	50,513	1,224,673	3,415,130
1920	1,402,881	626,012	46,948	1,255,282	3,331,124
1921	1,438,351	607,623	46,688	1,301,509	3,392,171
1922	1,486,345	587,419	44,958	1,321,794	3,440,516
1923	1,513,786	599,487	45,484	1,360,473	3,519,180
1924	1,639,535	586,109	49,926	1,465,610	3,741,180
1925	1,712,540	581,182	50,177	1,547,141	3,891,040
1926	1,819,285	596,760	53,300	1,667,848	4,137,193
1927	1,885,705	591,500	53,722	1,700,704	4,231,631
1928	1,825,105	575,907	52,278	1,547,194	4,000,484
1929	1,812,088	519,771	51,900	1,561,662	3,945,366
1930	1,877,364	513,468	54,304	1,657,269	4,102,405

Estimated numbers of sheep according to classes in Wales and Monmouth, 1867–1930.

Year.	*Ewes for breeding.*	*Rams and ram lambs to be used for service.*	*Other sheep.*		*Total sheep.*
			One year and over.	*Under one year.*	
1867	861,000*	25,800*	757,686*	765,660*	2,410,146†
1868	1,021,000	30,600	913,688	908,799	2,874,087
1869	1,021,000	30,600	963,796	907,418	2,922,814
1870	976,000	29,300	1,028,174	868,973	2,902,447
1871	975,000	29,300	1,012,900	867,919	2,885,119
1872	1,070,000	32,000	997,861	951,770	3,051,631
1873	1,096,000	32,900	1,070,140	975,105	3,174,145
1874	1,138,000	34,000	1,093,245	1,013,143	3,278,388
1875	1,043,000	31,000	1,161,635	927,758	3,163,393
1876	1,038,000	31,000	1,074,346	924,250	3,067,596
1877	1,060,000	32,000	1,016,411	942,636	3,051,047
1878	1,109,000	33,000	993,386	987,093	3,122,479
1879	1,022,000	31,000	1,079,193	908,768	3,040,961
1880	947,000	28,000	1,026,500	843,568	2,845,068
1881	814,000	24,000	1,022,100	724,247	2,584,347
1882	910,000	27,000	905,692	810,064	2,652,756
1883	963,000	29,000	878,045	856,513	2,726,558
1884	1,036,000	31,100	832,162	922,175	2,821,437
1885	1,102,000	33,000	837,038	980,576	2,952,614
1886	902,000	27,000	962,185	802,410	2,693,595
1887	1,118,000	33,600	774,631	995,671	2,921,902
1888	1,074,000	32,200	854,830	955,637	2,916,667
1889	1,143,000	34,200	826,462	1,016,598	3,020,260
1890	1,281,000	38,400	801,000	1,149,621	3,270,021
1891	1,313,000	39,400	939,206	1,168,624	3,460,230
1892	1,255,000	37,700	1,022,363	1,117,500	3,432,563
1893	1,221,000	37,000	963,752	1,092,733	3,314,485
1894	1,206,000	36,000	932,065	1,097,582	3,271,647
1895	1,216,000	36,400	913,832	1,036,833	3,203,115
1896	1,301,000	39,100	883,784	1,196,905	3,420,789

Year.	*Ewes for breeding.*	*Rams and ram lambs to be used for service.*	*Other sheep.*		*Total sheep.*
			One year and over.	*Under one year.*	
1897	1,824,000	39,700	878,180	1,157,829	3,399,709
1898	1,859,764	40,200	843,123	1,238,859	3,481,946
1899	1,424,257	42,700	870,298	1,302,288	3,639,543
1900	1,454,487	43,600	889,660	1,271,961	3,659,658
1901	1,459,016	43,800	859,467	1,293,383	3,655,666
1902	1,469,158	44,100	849,576	1,332,967	3,695,801
1903	1,498,202	44,900	841,333	1,364,163	3,748,598
1904	1,516,073	45,500	839,076	1,327,598	3,728,247
1905	1,534,296	46,000	822,092	1,365,532	3,767,920
1906	1,561,923	46,900	828,380	1,384,726	3,821,929
1907	1,616,385	48,500	828,532	1,450,444	3,943,861
1908	1,653,215	49,600	823,608	1,446,146	3,972,569
1909	1,698,567	50,800	840,944	1,468,255	4,053,566
1910	1,646,722	49,400	822,110	1,419,388	3,937,620
1911	1,613,157	48,400	803,146	1,364,689	3,829,392
1912	1,594,073	47,800	769,255	1,356,484	3,767,612
1913	1,512,462	45,400	771,881	1,270,192	3,599,885
1914	1,609,919	48,300	736,074	1,423,969	3,818,262
1915	1,668,594	50,100	722,960	1,484,686	3,926,340
1916	1,769,620	54,900	778,411	1,514,017	4,116,948
1917	1,727,772	55,300	724,806	1,390,020	3,897,898
1918	1,616,046	53,300	624,959	1,409,945	3,704,250
1919	1,478,458	50,513†	661,486†	1,224,673	3,415,130
1920	1,402,881	46,948	626,012	1,255,282	3,331,123
1921	1,433,351	46,688	607,623	1,304,509	3,392,171
1922	1,486,345	44,958	587,419	1,321,794	3,440,516
1923	1,513,736	45,484	599,487	1,360,473	3,519,180
1924	1,639,535	49,926	586,109	1,465,610	3,741,180
1925	1,712,540	50,177	581,182	1,547,141	3,891,040
1926	1,819,285	53,300	596,760	1,667,848	4,137,193
1927	1,885,705	53,722	591,500	1,700,704	4,231,631
1928	1,825,105	52,278	575,907	1,547,194	4,000,484
1929	1,812,033	51,900	519,771	1,561,662	3,945,366
1930	1,877,364	51,304	513,468	1,657,269	4,102,405

* Estimated. † Recorded.

SOME WELSH AGRICULTURAL WRITERS.[1]

By the Ven. Albert Owen Evans,

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It is an ill omen for the success of any paper when the writer has to confess at the outset that the field is bare, and the material is scanty. Still there is some excuse for this when all the circumstances are considered. Though agriculture is the oldest as well

[1] A paper read before the Bangor Branch of the Historical Association, 29th November, 1930.

as the most extensively followed of all callings, yet as far as England and Wales are concerned its survey and needs received but little attention publicly or officially till late in the eighteenth century. To-day more interest is shown, and none too soon, as agriculture is the largest single industry in the British Isles.

It did not appear to be the concern of any government till 1793, when the first Board of Agriculture was formed, and even then, this ceased to function in 1822. The later Board, now the Ministry of Agriculture, commenced its operations in 1889. The prime mover in the formation of the first Board was Sir John Sinclair (1754-1835), who was appointed President. He had already formed the Highland Society, and by memorialising the parish ministers of Scotland for information he had obtained a survey of the state of agriculture in Scotland (1791-9). When he became President of the Board of Agriculture he proposed that a similar step should be taken in England and Wales by sending a form of enquiry to all the parochial clergy, but this was objected to by Archbishop Moore of Canterbury, and so the enquiry had to be made in another way. A number of men were sent to each county to gather such information as they were able to glean, and their reports were published in counties. Arthur Young (1741-1820) called the reports " a wretched mass of erroneous and insufficient information ". It has been well said of Young that he was " an agricultural writer who is never likely to be matched ". His " Annals of Agriculture " (1784-1809), as well as his " Tours " (1768-89), stand as monuments to his great industry and zest, as well as to his ability and skill. His " Travels in France " during the years 1787, 1788, and 1789, alone would ensure for him a foremost and permanent place among writers on agriculture and kindred subjects, as they are unique. It may be well to add a word of caution with regard to these French tours. Whatever be the ambition and hopes of Welsh agricultural writers it must not be forgotten that Arthur Young was favoured with France as a background, for it has the vine, the mulberry, and the olive, indigenous to the soil, and undoubtedly they assisted in the production of a delightful book which has a charm all of its own. You would remember that Miss Betham-Edwards, who edited an issue of the Tours, remarks in her introduction that this book, translated into French, is familiar to every schoolboy in France. Would that we had in Wales a book on similar lines on Wales respecting which the same might be said! It is to be feared that this is not to be expected till some Dahl or a fellow-countryman be sent to make a survey of Wales and tell us without fear

or favour what his views were on the entire situation. Lord Ernle, in his *English Farming Past and Present*, has served our neighbours well in this respect. It first appeared in 1912, and by now the book has been issued for the fifth time, and each issue increases its attractiveness and completeness.

It would serve our present purposes to give here a short conspectus, as to when different societies were formed in Wales, which had for their object the improvement of agriculture in the various districts where they operated, and at the same time mention the dates of similar movements in England and elsewhere.

The *Brecon* Society printed its articles or rules in 1755, and an annual report was printed each year afterwards showing the progress made by the Society, as well as giving lists of premiums offered for various efforts. The Brecon Society was one of the earliest in the kingdom, and its initial success was due to a large extent to Sir Edward Williams, of Llangoed Castle.

The *Glamorgan* Society, with its headquarters at Cowbridge, commenced operations in 1772. In 1890, John Garsed published " Records of the Glamorgan Agricultural Society ".

The *Bath and West of England* Society was started in 1777.

The *Highland* Society dates from 1784.

The *Cardiganshire* Society began in the same year—1784.

The *Wrexham and District* Society was formed in 1796, with an off-shoot for *Wynnstay* in 1806.

The *Merionethshire* Society was established in 1802.

The *Carmarthenshire* Society started in the same year—1802.

The *Radnor* Society about 1806.

The *Caernarvonshire* Society in 1807.

The *Anglesey* Society in 1808.

The *Vale of Clwyd* Society, or Farmers' Club, in 1810.

The *Pembroke* Society or Farmers' Club in 1813.

The *Royal Agricultural* Society in 1838.

Most of these Societies were organised on a premium system and each had particular and peculiar features of its own. Colloquially in these parts the country people even now refer to an Agricultural Show, whether it be Horse, Cattle, or Horticultural, as a *Preimin*. The Brecon Society in 1755 encouraged the improvement of roads by offering a grant of money to each parish in Breconshire on the high-road between the counties of Hereford and Carmarthen for the improvement of the said road. In 1757 this Society extended the same bounties for the benefit of other roads. After this date sums of money were raised by Acts of Parliament for this purpose, and so these grants fell into

abeyance. Anglesey in its list of rewards, gave one for the saving of sufferers in cases of shipwrecks.

It need not be said that all these Societies were voluntary, and not State-aided. Many well-known names could be mentioned in connection with these efforts. The successive years of the operation of these Societies brought their respective reports, and these must be reckoned as forming a very important part in the history of the agricultural life of Wales. A review of these reports is much to be desired. It would be well if an effort were made to collect these fleeting and ephemeral reports and house them together, as they give a most important chapter in the past history of agriculture in Wales. They should be made accessible to students of the agricultural, economic and political movements in the Principality.

Probably the personal interest shown by George III, and more especially his letter of appeal to the country gave an impetus to the movement, and made the calling of agriculture fashionable. The exigencies of the times made it imperative that attention should be called to the need of obtaining more produce from the soil, and this could not be secured without a complete change in the primitive methods which then obtained generally throughout the country. The gradual advance in the price of farm produce soon after the year 1760, occasioned by the increase of population and of wealth derived from manufactures and commerce, gave a powerful stimulus to rural industry, augmented agricultural capital, and called forth a more skilful and enterprising race of farmers. The unpropitious weather of 1816 and 1817, and still more the passing in 1819 of the Bill restoring cash payments in connection with the tenure of farm lands, combined with the aftermath of the Napoleonic Wars, all tended on account of the poverty-stricken conditions in rural districts, to direct attention in the same direction. The period of great depression lasted till the early Forties.

In and about 1794, the Government, through the Board of Agriculture, undertook a complete survey of the whole of England and Wales, and these reports were afterwards printed and published. They contained a view of the state of agriculture in the various counties, and included observations on the means for its improvement for the consideration of the Board of Agriculture.

Brecon was surveyed by John Clark of Builth, steward to Viscount Hereford, and his report contains fifty-five pages. Clark also produced one for *Radnor* (41 pp.). The *Cardigan* report was the combined work of Thomas Lloyd of Cilgwyn and

the Reverend David Turnour (87 pp.). The latter mentioned was Rector of Manordeivy [*ob.* 1799], and shares with Thomas Johnes of Hafod, near Aberystwyth, the honour of founding the Cardigan Society. *Carmarthen* was surveyed by Charles Hassall (52 pp.), who also reported on *Pembroke*. *North Wales* was produced by George Kay of Leith, as follows :—

Flintshire (24 pp.).
Anglesey (29 pp.).
Carnarvonshire (22 pp.).
Montgomery (22 pp.).
Merioneth (16 pp.).
Denbighshire (16 pp.).

These six reports were all printed in one volume, and at the end there are thirty-nine pages devoted to hints for improvements.

The report for Glamorgan for some reason or other was not published till 1796. While following on the same lines as the other reports, it appears to be fuller and more complete. It fills seventy-one pages, and was written by John Fox. After an introduction, the author has general remarks on the physical features of the county, then a chapter on its rivers (possibly with a view to improving the water communications of the county). Then follow chapters on the national produce, trade, climate, places of note, soil, domains, and occupations of the county of Glamorgan. The chapter on occupations refers to the size of the farms, employment of lands, cultivation of grasses, species of stock, poultry, watering of land, what grains were cultivated, drilling and dibbling, pulse, turnips and rotation of crops.

That the Board of Agriculture was hardly satisfied with these reports may be inferred from the fact that in 1810 a fuller and a more complete volume was published for North Wales by the Board. This was the work of Walter Davies (1761-1849), better known by the name of Gwallter Mechain, who at the time was Rector of Manafon in Montgomeryshire. It is a volume of 510 pages, and shows a distinct advance in every direction on its predecessors. Had Walter Davies been a poorer Welsh poet in all probability his work would have claimed greater attention than it has obtained. The book is entitled *General View of the Agriculture and Domestic Economy of North Wales*. It is a very comprehensive account of the then state of affairs, and contains much interesting information. His economic statements are most valuable and seem to be very reliable. In his introduction the author does not refer to any source of help or assistance, but the compilation of such a report must have involved much travelling and enquiry. It might be suggested that most of his

facts and figures were obtained through the local clergy, as was the case with Samuel Lewis's "Topographical Dictionary" (1831). At times attempts are made in the book to derive technical terms on lines with which we generally associate the lexicographer, William Owen Pughe. Still the survey for the times was great and even now bears perusal and study. It contains one sentence which is of the greatest interest to the Agricultural Department of the University College of Bangor:—"The flat tract of Aber, opposite Beaumaris, is a spot capable of great improvement; but all the means leading thereto are entirely neglected". This must be the site of the present Bangor University farm. Whether Walter Davies should be credited for this remark, or should we attribute it to Hugh Davies (1789?—1821), the then Rector of Aber, is difficult to decide. Hugh Davies was the author of *Welsh Botanology* (1813), which for the times was a scholarly work, and contains xvi + 255 pages. He also contributed the whole of Thomas Pennant's *Indian Zoology* (1790), with the exception of the chapter on insects. His *Herbarium* is in the British Museum, still unpublished.

The survey of Walter Davies contains seventeen chapters, dealing with:—

1. Geographical state and circumstances.
2. State of property.
3. Buildings.
4. Mode of occupation.
5. Implements.
6. Enclosures.
7. Arable lands.
8. Grass.
9. Gardens and orchards.
10. Woods and plantations.
11. Wastes.
12. Improvements in general.
13. Live stocks.
14. Rural economy.
15. Political economy.
16. Obstacles to improvements.
17. Miscellaneous observations.

It concludes with ten appendices, which command attention as they are culled from many sources, and are of a distinct historical value.

In 1814, Walter Davies produced a *Survey of South Wales*, in two volumes (pp. 613 and 586). In this Survey he acknowledges the great assistance he had derived from Edward Williams,

the famous Iolo Morganwg, as well as from many laymen and clergymen in the various counties. This work follows on similar lines the issue of 1810 for North Wales.

Most of the above must be looked upon as official and Departmental documents, and as produced by experts. When we deal with our subject from a personal and individual angle, we are supplied with a very exhaustive list of publications dealing with Agriculture and Land Tenure in Wales and Monmouthshire which was compiled by Sir D. Lleufer Thomas, the then Secretary of the Royal Commission on Land in Wales. The list appears as Appendix B and C of the Commissioners' report (page 79 -205), and is dated 1906. Here will be found references to almost all conceivable sources of information on the agriculture of Wales, with short notes on the several books mentioned. While admiring the great industry and care shown in the compilation of the list, yet it must be admitted that many of the references to agriculture found in many of the books mentioned are but casual. Just as we find in the *Breviary of Britayne* (1578) by Humphrey Llwyd (1527-1568) that in his time there was much corn in the Vale of Clwyd, a good supply of cattle in Caernarvonshire, and many deer and goats in Merioneth, which is very interesting to the ordinary reader, but it does not give us much enlightenment on the subject of agriculture.

Another book which was an outcome of the Land Commission was *The Welsh People*, in which Sir John Rhys and Sir David Brynmor-Jones collaborated, but it only refers slightly to agriculture, and with the exception of a chapter on Land Tenure in Wales, is very disappointing.

Outside of these official surveys, one must come to the conclusion that Wales possessed only one serious attempt which is confined to agriculture pure and simple, and that is *Idea Agriculturae* by Henry Rowlands (1655-1723), the author of *Mona Antiqua*. Its title page states :—" *The principles of vegetation asserted and defended. Being an essay on the theory and practice of husbandry: proceeding on the three noted mediums of improvement, viz., marle, lime, and shells. Principally relating to the Isle of Anglesey with rules and directions to find out the latter (wonderful in fertilising the barrenest land) on other shores of Great Britain and Ireland, where the like beds of broken shells, the winnowings of the sea, must naturally lie, if the like vast plenty of shell-fish do breed on the coasts, and in all probability will be found, if they be sought for, according to these directions. By Henry Rowlands, Vicar of Llanidan, Anglesey* ". The work

apparently had been written in 1704, from the date of its introduction, but it was not published till 1764 (in Dublin), forty-one years after the death of the author. Mr. Bryner Jones, in an article on this book in the *Geninen*, maintains that there is internal evidence that parts of it, at least, had been written as early as 1699. This, I consider, is one of the books which should be re-published, as apart from the subject of agriculture, it is of real value to-day on account of its historical data. The references it contains to local efforts with names of men and places are most interesting, and its re-issue would be welcomed by many. It is a credit to Wales. In its earlier chapters are many quotations from the classics which was in strict accordance with the literary style of the times.

While discussing *Idea Agriculturæ*, one's mind naturally turns to Thomas Owen, of Rhiwlas, Anglesey (1748-1812). He entered Jesus College, Oxford, in 1767, and took his degree in 1770. He migrated to Queen's College soon after, and became a Fellow of that College. He was appointed Rector of Upton Scudamore, Wiltshire, in 1779, and held his Fellowship and Benefice to his death in 1812. He was buried at Pentraeth, Anglesey, his native parish. He translated and published :—

1. The three books of M. Terrentius Varro concerning Agriculture, 1800 (257 pages). Price 5/6.
2. M. Porcius Cato, concerning Agriculture, 1803 (144 pp.).
3. Geoponica—Agricultural pursuits,
   First volume, 1805 (298 pp.).
   Second volume, 1806 (301 pp.). Price 15/-.
4. Palladius Rutilius Taurus Aemilianus de re rustica. The fourteen books on Agriculture, 1807 (349 pp.). Price 8/-.

The last mentioned must be a very scarce book, as though I enquired at the British Museum, Bodleian, John Rylands, the Welsh National Library, and Cardiff, I failed to find a copy. It was only when I wrote to Queen's College, Oxford, that I was successful in discovering a copy. Donaldson, the agricultural writer, adjudged the work of Thomas Owen as " an honest performance ". Lately a fragment of a diary kept by Thomas Owen has come to light, and is now housed in the Library of the Bangor University College. It covers the period January 1st, 1807, to April 30th, 1811. It shows him as a diligent and a zealous agriculturist in every department.

In 1873 Barton Lodge, Rector of Colchester, edited for the Early English Text Society, *Palladius on Husbondrie* from a manuscript of about 1420 which had been found in Colchester

Castle. The Editor, in his preface, writes, " that he was not aware of the existence of any translation of Palladius into English, though he had been published in the vernacular of most other European nations ". Seemingly he was unaware of the translation of Thomas Owen. The Colchester manuscript was in verse and so as a translation had many limitations, whereas the work of Thomas Owen was in prose. From the introductory matter in these various volumes attention is called to the fact that a careful collation had been made with the Eastern translations in which they are to be found.

Here we must refer to Thomas Johnes (1748-1816) of Hafod. It was said of him, " he was fully as eager to carry on undisturbed his many schemes on his estate, as he was anxious to publish his translations from the old French chronicles ". His must have been a charming and coveted round of daily tasks. He set up his own printing press on his estate, and among other productions he issued several pamphlets on agriculture, and among them, *Proceedings of the Cardiganshire Agriculture Society* between the years 1808 and 1810, under the supervision of James Henderson. The first number of these Cardiganshire reports was printed by Ross of Carmarthen in 1792. A very valuable monograph was issued by Johnes from Bristol entitled *A Cardiganshire Landlord's advice to his Tenants*, 1800 (134 pp.). This was translated into Welsh by Dr. William Owen Pughe, and published in the same year, 1800 (136 pp.). Another contribution by Johnes was a re-print of a short treatise from the *Edinburgh Review* of May, 1800, *An account of the mode and expense of cultivating moors and peat-lands*, 1800 (16 pp.).

There is one monograph which deserves to be noticed, and that is one printed in 1755 by an anonymous writer from Pembroke who called himself Giraldus Cambrensis. A second edition appeared in 1762. It was entitled *Proposals for enriching the Principality of Wales humbly submitted to the consideration of his countrymen.* The pamphlet was printed at Gloucester and consists of only forty-seven pages, but it contains much interesting matter, and was a thoughtful attempt to assist as well as to give an entertaining account of how cattle were removed from Wales to English markets, with the prices and profits obtained. He mentions two other pamphlets which I have failed to trace. From the information one may gather that the barrel churn was looked upon as a great invention and improvement. This was the time when clover and turnips were coming into favour for feeding cattle. He makes what he considered at the time an

important suggestion that there should be enclosures for sheep if the property of one man.

One of the earliest booklets in Welsh was by David Thomas in 1816 (58 pp.) from Caernarvon, on the *Practical cultivation of land* (Arddwriaeth ymarferol, sef, traethiadau ynghylch llafurio tir, y rhai a dderbyniasant gymeradwyaeth a chefnogaeth aelodau Cymdeithasau Arddwriaethol Mon ac Arfon, ynghyd ac amryw Foneddigion ereill. O gasgliad Dafydd Thomas, Caernarfon).

From Carmarthen in 1824 came a pamphlet of thirty pages, entitled, *Management of Farm Manure*, by Alfred Thomas, Land and Tithe-surveyor; which is quite good on the nature and qualities of soils.

It appears that all these attempts were quite serious.

A very interesting leaflet by J. H. Bransby of Caernarvon on *Characteristics of Snowdon sheep*, was issued in 1885.

The Beaumaris Eisteddfod held in 1882 was the means of bringing out three essays, which were all published, and that in Welsh. A prize was offered at Beaumaris for a Treatise on Agriculture. It was awarded to Aneurin Owen, a son of William Owen Pughe. This was printed in 1839 (49 pp.). In the preface it states " This little treatise has been composed with the view of affording the Welsh peasantry some insight into methods of culture, practised in various parts of England, which are suitable to the soil and climate of Wales, and which it might be beneficial to adopt ".

Another pamphlet on the same subject was by Morris Hughes, Portdinorwic (38 pp.), and published in 1883.

The third was by the Reverend Samuel Roberts, Llanbrynmair, 1882 (72 pp.).

In 1885 the Anglesey Agricultural Society brought out in Welsh a very well written monograph on the cattle of Anglesey. This was also, I understand, issued in English.

A very useful and practical leaflet of twelve pages was issued in Welsh in 1839 on the management of poultry. This was anonymous, but written by an Anglesey man and published in Bangor—*Ychydig Hyfforddiant ar Driniad Dôf-adar (Poultry), gan modryb Sian, o Dindaethwy.* (12 pp.).

About this time single articles on different aspects of the agricultural industry began to be written for contemporary magazines, both in English as well as in Welsh.

The most ambitious of these was " *On the state of Agriculture and the progress of Arts and Manufactures in Britain during the period and under the influence of the Druidical System*, by

the Reverend John Jones, Rector of Llanllyfni, and was an offset of the Cambrian Archaeological Magazine, 1851 (22 pp.). This was a strange mixture of facts and fables, and was quite in accordance with the Welsh aspirations of the period.

The then Earl Cawdor offered a prize of £10 through the Carmarthenshire Agricultural Society for an essay on the *Use and abuse of lime as a manure.* This was awarded to Thomas Morgan, of Maesgwrda, and was printed in 1851 (22 pp.). This also appeared in Welsh in the same year.

Dr. Owen Owen Roberts, of Bangor, in 1845 wrote *Observations on thorough Drainage as the basis of agricultural prosperity.* (40 pp.). He seems to follow closely a booklet by James Smith, of Deanston (1885).

Lest it be thought that cottagers were forgotten, a most useful handbook was written and published by Charles Ewing of Bodorgan, in Welsh—*Gardening book for the farmer and cottager*, 1860 (100 pp.).

The late Col. Stapleton-Cotton followed on similar lines in 1910, with a monograph of seventy-two pages in Welsh.

The Rhuddlan Eisteddfod of 1850 offered two prizes, one on the *System best adapted for the cultivation of the uplands of Wales* and the other *for the lowlands.* The former prize was awarded to the Reverend R. H. Jackson, of Newmarket, Flintshire, and it was published both in English and Welsh (82 pp.). The latter was taken by John Hughes, Llanerchymedd, and was published in Welsh (80 pp.).

The Conway Eisteddfod of 1861 offered a prize for an essay on *The proper selection of stock and the breeding of cattle.* The prize was divided between the Reverend John Owen, Tynllwyn, near Bangor (1808-1876), and John Edwards, Veterinary Surgeon, Abergele. The two essays were published in one book (80 pp.). Though not showing any extensive reading or research, they are quite useful in their way. They were in Welsh.

In 1869, John Owen published another pamphlet in Welsh (60 pp.) on the *Selection, Breeding, and Care of Live Stock,* with notes by Chancellor James Williams, Llanfairynghornwy (1790-1872). This was the prize essay of the Chester Eisteddfod of the previous year. In the booklet he pays a tribute to Chancellor Williams for his interest in the Agriculture of the neighbourhood during a period of fifty years.

I will close my list by mentioning a very useful addition to our knowledge of Agriculture in Wales. It was written and produced by John Gibson, the then Editor of the *Cambrian News*, in 1879. Its 142 pages present practical and useful observations on

the state of Agriculture in Wales at that time, with many shrewd suggestions for its improvement.

In 1814 there came out of the press a Veterinary Guide by a C. Griffiths, in Welsh *(Meddyg anifeiliaid neu Pob dyn yn feddyg i'w anifail ei hun)*. It was a book of 368 pages, and was apparently a translation. Possibly this was the first of its kind in Welsh. In 1816 we find *A practical guide to those who have live stock* (372 pages), written by John Edwards, of Llanychan. (*Y cyfarwyddyd profedig i bob perchen anifeiliaid*). This book went through several editions. The Reverend David Jones, Pontarfon, Llandeilo Fawr (1788-1859) wrote a treatise on *The horse*. It was published posthumously on 1862 (186 pp.). It appears that he had also ready for the press similar essays on the cow, the sheep, and the pig, but these were never published.

William Griffith, Groom at Wynnstay, wrote a *Practical Treatise on Farriery*, and published it at Wrexham in 1784.

There were other books or pamphlets which were mainly translations from English sources. Wales early last century was much indebted for small handbooks on agricultural subjects, published by the Society for Promoting Christian Knowledge and the Society for the Diffusion of Useful Knowledge. Later, Hugh Humphreys, Publisher, Caernarvon, did most useful work by producing in small books in Welsh, translations from the English, on different subjects in connection with Agriculture.

I have refrained from referring to ancient Welsh laws with respect to the tenure of land in Wales, as I do not feel that I am competent to discuss the question, and in addition, there are no books as far as I could discover in Wales or in Welsh bearing directly on the question. To my mind there is room for a book on what might be termed a comparative study of Celtic Tenure of land. Little is said in the various books mentioned by Sir D. Lleufer Thomas in his list, on either Tanistry or Metayage. The spirit of the latter is still frequently met with in Anglesey. A man places a family in a farm and becomes responsible for the rent and rates, provides the money for purchasing what is compulsory and necessary from the old tenant, and stocks the land, and shares with the tenant in the proceeds. But such a transaction is never published and much depends on the sense of honour and justice of the two parties.

I would call attention to Hubert Lewis's *The ancient laws of Wales* (1889), but it requires annotation for practical purposes.

Little is found among the old Welsh manuscripts written on Agriculture. It is to be feared that there is much truth in what

Geoffrey of Monmouth wrote in his *Historia Britonum* of the Welsh at the time of the Crusaders, that they left their " hunting and fishing " to take up the Cross. This probably was the case till circumstances compelled them to take Agriculture up more seriously.

I did not think that you expected that I should refer to the numerous lists of papers and tracts which have been issued from 1878 from the University College of Wales, Aberystwyth, as well as from Bangor since 1891. No doubt these will be valuable assets in time to describe the advance of Agricultural education.

As was said by a lecturer on Greek agriculture some little time ago, it might also be asserted of the history of Welsh agriculture (mutatis mutandis), " Varro gives a list of some fifty Greek writers who composed monographs in Greek on different branches of the subject, and in consequence our knowledge of Greek agriculture must be supplemented from casual references in other writers ". Our Welsh writers on Welsh agriculture gave us monographs.

Still, we have in Welsh what I do not think will be found in any other language. They are handbooks which are called *The Shepherd's Companion*, which contain many thousand earmarks of sheep, mostly in Merioneth, Montgomery, Cardigan, Carmarthen, Brecon, and Pembroke. These are :—

1. *Clustnodydd*, by John Roberts, Rhydyfelin, with additions by R. Roberts and R. Jones, Henfache, Llanrhaiadr-ym-Mochnant, 1868 (88 pp.).
2. *Cydymaith y Bugail*, by Lewis Jones, Blwch, Dinas Mawddwy, 1888 (267 pp.).
3. *Clustnodydd neu Logell Lyfr y Bugail* (The Shepherd's pocket-book), by Hugh Ellis, Blaenpennant, 1905 (108 pp.).
4. *Cyfarwyddwr y Bugail*, by John Jones, Park Owen, Gwynfe, and J. Llewelyn Evans, Blaencenau, Gwynfe, 1910 (172 pp.).
5. *Llyfr Nodau neu Llaw-lyfr Bugeiliaid Mynydd Preseli*, by R. Davies, 1924 (28 pp.).
6. *Llyfr Nodau (Ail-gasgliad)*, R. Davies (with pony marks), N.D. (8 pp.).

In passing, it is interesting to notice that several of the old-fashioned farmers in Anglesey and Lleyn still earmark their cattle as their fore-fathers did in the days when there were no enclosures. Unfortunately the Welsh cattle dog par excellence, the corgi, has disappeared from North Wales, but successful

efforts are being made in Carmarthen and Pembroke to revive the breed.

Nothing would be more appropriate than to close my paper with a quotation from Dean Swift, which will be found in one of the journeys in Gulliver's Travels :—

" And he gave it for his opinion, that whoever made two ears of corn, or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together ".[2]

I.—THE EFFECT OF WILD WHITE CLOVER ON THE LIVE WEIGHT INCREMENTS FROM A TEMPORARY PASTURE

II.—A COMPARISON OF TEMPORARY AND PERMANENT PASTURE.

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I.

This trial was laid down in 1927 at the College Farm of the University College of North Wales, Bangor, when an 8 acre field was seeded down to grass in such a way that one half received 1 lb. per acre wild white clover seed and the other none of this constituent. Thus two plots were obtained, each of 4 acres, differing only in that one received wild white clover when sown down and the other none. The former will be referred to as plot WW, and the latter as plot OW. A description of the trial, with the results for the grazing season of 1930, has been given elsewhere (1). The results for 1930 may be summarized by stating that the live weight increase from plot WW amounted to 593 lb. per acre, and that from plot OW to 437 lb. per acre; there was thus a gain of 36 per cent. due to including wild white clover in the seeds mixture three years previously. This was due mostly to the increased stock-carrying capacity of plot WW, and not to the individual animals on this plot increasing in weight at a greater rate than those on the other plot. An analysis of turves from the plots, carried out in May, 1930, showed that there was 30 per cent. of wild white clover in plot WW, and 10 per cent. in the other plot.

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[2] *Gulliver's Travels. A voyage to Brobdingnag*, p. 126. (Dublin, Geo. Falkner, 1774).

Stocking of plots, 1931.

During the previous winter both plots had been grazed intermittently by sheep. No record of the grazing was kept, but as the plots were well eaten down in autumn, the amount was small. Careful attention was given to stocking the plots, so as to ensure that neither plot should be placed at a disadvantage through being over- or under-stocked. All stock was taken off both plots on the 27th of April, and the experimental area was kept free of stock until the 8th of May, the date of the commencement of the trial for the 1931 season. On this date five Welsh mountain ewes, each with one wether lamb, sired by a Welsh ram, were put to the acre on plot WW, and four similar ewes, each with one lamb, to the acre on plot OW. The same precautions were taken in 1931 as in 1930 to ensure that, as far as possible, the stock put on the plots should differ only in numbers, and should be alike in all other respects. The amount of grass was not sufficient for cattle to be put on the experimental area until the 23rd of May, when three in-calf heifers were taken to each plot. The cattle remained on the plots until the 29th of September, when the trial was concluded for the season. The ewes and lambs were removed from the plots on the 26th of June, and the experimental area was free of all sheep until the 16th of July. On this date, twenty-four Welsh wether lambs which had been weaned from mountain ewes at shearing time were taken to plot WW and eighteen to plot OW; these sheep remained on the plots until the 28th of September. Table I shows the stock carried by both plots throughout

TABLE I.

Stock carried—May 8 to September 29, 1931.

Period during which plots carried stock.	*Plot WW (4 acres). Wild white clover sown.*	*Plot OW (4 acres). No wild white clover sown.*
May 8—June 26	20 ewes, of average weight, 70 lb.	16 ewes, of average weight, 70 lb.
ditto.	20 lambs, of average weight, 26 lb.	16 lambs, of average weight, 26 lb.
July 16—Sept. 28	24 wethers, of average weight, 46 lb.	18 wethers, of average weight, 45 lb.
May 23—Sept. 29	3 heifers, of average weight, 667 lb.	3 heifers, of average weight, 663 lb.

the season, and also the average live weight per head of each class of stock when first put on the plots.

Thus plot WW carried one ewe and one lamb to the acre more than plot OW from May 8 to June 26. From July 16 to

September 28 plot WW had 1.5 more wethers to the acre than Plot OW. The cattle carried by both plots did not differ at any period during the season. Although the wild white clover plot carried more stock than the other, there was rather more grass on it throughout the season.

Appearance of plots, and composition of herbage.

On the 27th of April both plots were uniformly bare, but green. From a distance no difference could be distinguished between the plots, but closer inspection showed that there was a greater proportion of daisies in plot OW. Early in May the daisies were in flower, and the difference in the appearance of the plots became easily discernible from a distance. There was more grass on plot WW throughout the season, though its superiority was not so obvious as in the previous season. A botanical analysis of representative turves taken from the plots on the 8th October was carried out by Dr. Alun Roberts. The proportions of the principal constituents of the herbage are shown in the following table, and expressed as percentages by weight.

TABLE II.

	Plot WW.	*Plot OW.*
Cocksfoot ...	5.1	0.9
Crested dogstail ...	1.2	0.6
Perennial ryegrass ...	39.7	40.3
Rough stalked meadow grass ...	3.4	11.4
Bent grass ...	16.0	17.0
Wild white clover ...	10.9	5.2
Miscellaneous ...	23.7	24.6
	100.0	100.0

There is thus twice as much wild white clover in plot WW as in plot OW. As the proportion of this constituent was three times as high in plot WW in the previous year, it appears as if the proportion of indigenous wild white clover has increased in the interval. As the 1981 analysis was carried out in October, and that of 1980 in May, the increase or decrease in the proportion of a constituent cannot be found merely by a comparison of its proportion in the two years. It has been shown (2) that wild white clover, for example, makes a smaller contribution to the herbage in autumn and winter than in summer, and it is probable

that the proportion of this constituent would have been greater had the analysis been carried out at an earlier date.

Table III shows the rainfall for each month from April-September, 1931.

TABLE III.

Rainfall at Aber, April—September, 1931.

Month.	*Rainfall in inches.*
April ...	3.52
May ...	1.93
June ...	3.19
July ...	2.21
August ...	5.80
September ...	3.52
Total ...	10.17

The rainfall during the season was favourable for grass production, and there was no drought in May and June.

Live weight increase from plots.

Table IV shows the live weight increase given by both plots, the increase per acre, the mean live weight increase per head for each class of stock, and also the ratio of production obtained by putting the increase on plot OW at 100.

TABLE IV.

Increase in live weight, 1931 (per plot).

Class of stock.	*Plot WW.*		*Plot OW.*	
	Mean increase per head of stock (lb.).	*Total increase (lb.).*	*Mean increase per head of stock (lb.).*	*Total increase (lb.).*
Ewes ...	12.1	243	12.2	193.5
Lambs ...	28.5	570	27.0	430.5
Wethers ...	12.6	304	12.5	225.5
Heifers ...	289	868	256.5	779.0
Ewes and lambs and heifers ...	—	1,985	—	1619.5
Ditto, per acre ...	—	496	—	405
Ratio of production for season ...	—	122.5	—	100

The total increase in live weight per acre made by the stock grazing plot WW amounted to 496 lb. against 405 lb. by the stock on plot OW. If the increase from plot OW is placed at 100, that

from plot WW becomes 122.5; there is thus a gain of 22.5 per cent. in the fourth year due to including wild white clover when seeding down. The corresponding figure for 1930 was 86 per cent. The difference may be due to the increasing colonisation of wild white clover in plot OW tending to equalise production on the two plots; the botanical analysis of the herbage disclosed the fact that in 1930 there was three times as much wild white clover in plot WW as in OW, and in 1931 there was twice as much.

It can be seen from Table IV that the superiority of plot WW, when the results are expressed in terms of live weight increase, is due mostly to the greater head of stock carried. and not to the stock on plot WW making greater live weight increase than those on plot OW. The ewes and wethers made almost identical increases in the case of both plots. The lambs on plot WW were 1.5 lb. heavier when taken off than those on the no wild white clover plot, and the heifers on the former were, on the average, 33 lb. heavier than those on the latter. These conclusions confirm those of the previous year, viz., that the greater gain in live weight from the wild white clover plot was due mostly to the larger head of stock carried, but that there was also a slightly greater mean increase per head in the case of the stock grazing plot WW. This also shows that the plot OW was not handicapped by being understocked.

The productivity of the plots may also be compared on the basis of the number of days of grazing afforded to the different classes of stock. Under certain conditions, this method is preferable to the method of comparison on the basis of liveweight increase. For example, should the soil or seasonal conditions be such that the grassland can only maintain the animals in store condition, the method of comparison on the basis of live weight increase would not reveal any greater stock carrying capacity on one plot. The comparison of the plots on the basis of the number of days' grazing provided is given below.

Kind of stock.	*Number of grazing days afforded.*		*WW : OW*
	Plot WW.	*Plot OW.*	
Sheep ...	3.736	2,900	129 : 100
Cattle ...	387	387	100 : 100

Thus the amount of grazing afforded to cattle was the same on both plots, but plot WW provided 29 per cent. more grazing for sheep.

The increased productivity as a result of the inclusion of wild white clover when seeding down is economically important owing to the comparatively low initial expenditure (price of the seed), the non-recurring nature of the expense, and also owing to the length of time during which the improvement continues to be evident. This mode of improvement contrasts sharply with methods requiring heavy initial outlay, recurrent annual expenditure, and which in many cases tend to have a deteriorating influence on the turf after a few years. Another interesting feature is to be found in the fact that the improvement due to sowing wild white clover becomes evident even although the plot is compared with one that is already of a high order of productivity; thus, the no wild white clover plot produced a live weight increase of 437 lb. for the summer of 1930, and of 405 lb. in 1931.

There was no noticeable difference in the health of the stock in 1931, the stock thriving well on both plots. In the previous year a greater tendency to scour was noticed amongst the ewes and cattle on the wild white clover plot, but in 1931 there was very little difference in this respect.

Conclusions.

The effect of including wild white clover in the seeds mixture when seeding down has been tested in the fourth year of a temporary pasture; the comparison has been made on the basis of live weight increase. A botanical analysis of the herbage reveals the fact that whereas the amount of wild white clover on plot OW was one-third of that in plot WW in 1930, there was one-half as much of this constituent as in plot WW in 1931.

The plot on which wild white clover had been sown produced 496 lb. live weight increase per acre, against 405 lb. in plot OW; there was thus a gain of 22.5 per cent. in productivity.

The gain in productivity was due more to the increased stock carrying capacity than to greater gains in live weight being made by the stock grazing the wild white clover plot.

* * *

II.

A comparison of the grazing qualities of temporary and permanent pasture was begun at the same farm in 1931, good permanent pasture being compared with the two temporary pasture plots (WW and OW) in the wild white clover trial. The permanent pasture consisted of a 7 acre field adequately provided with water and shelter; it has not been under the plough within living memory, and has always been considered an

excellent pasture. A botanical analysis of the herbage made in October, 1931, shows the following composition, expressed in percentage weight :—

Cocksfoot	5.0
Crested dogstail	0.9
Perennial ryegrass	5.1
Rough-stalked meadow grass	2.3
Yorkshire fog	28.5
Bent grass	44.4
Wild white clover	2.0
Red fescue	10.0
Miscellaneous	1.8
	100.0

The analysis reveals a high proportion of bent grass and Yorkshire fog, and a lower proportion of perennial rye-grass and wild white clover as compared with the two temporary pasture plots.

Stocking.

The trial commenced on the same date as the wild white clover trial, and the permanent pasture was stocked with the same class of stock as plots WW and OW of the trial; in this way the results of the season's grazing of the permanent pasture become comparable with those of the temporary pasture plots. Table I (above) shows the stocking of the temporary pasture plots throughout the season, and also the average weight of sheep and cattle used in the trial. The stock used for the permanent pasture was of the same average weight as that of the temporary pasture, and the dates on which the different classes of stock were put on and taken off the plots were identical. On the 8th of May, twenty-nine ewes and twenty-nine lambs were taken to the permanent pasture (7 acres). These were removed on the 26th of June; the land was free of sheep until the 16th of July, when thirty-eight wethers were put on this pasture, and left there until the 28th of September. Four in-calf heifers grazed this field throughout the season. This pasture thus carried a rather smaller head of sheep than the better temporary pasture plot (WW), and only carried four cattle to seven acres as against three cattle to four acres for each of the temporary pasture plots.

Effect on stock.

Table V gives the average weights of the sheep and cattle at various dates during the season on both the permanent and

temporary pastures. A comparison of the increase in weight of the ewes and lambs put on the plots on the 8th of May shows an interesting although small difference. The lambs showed no difference, but the ewes on the permanent pasture only increased by an average of 7 lb. per head, while those on plots WW and OW increased by 12 lb. It appears as if the temporary pasture provided the ewes with more surplus digestible nutrients over and above the amount required for milk production than the permanent pasture.

TABLE V.

Average weight in lb. per head of stock.

Date of weighing.	Permanent pasture.					Temporary pasture.									
						Plot WW.					Plot OW.				
	Lambs.	Ewes.	Wethers.	Heifers.		Lambs.	Ewes.	Wethers.	Heifers.		Lambs.	Ewes.	Wethers.	Heifers.	
May 8	27.0	70.0	—	—		25.8	70.4	—	—		26.0	70.3	—	—	
May 23	—	—	—	713		—	—	—	667		—	—	—	663	
May 29	39.5	75.2	—	768		40.3	80.4	—	726		39.0	79.5	—	742	
June 6	—	—	—	819		—	—	—	793		—	—	—	793	
June 26	53.7	77.4	—	—		54.2	82.5	—	—		53.0	82.5	—	—	
July 16	—	—	45.8	—		—	—	46.0	—		—	—	45.0	—	
Aug. 15	—	—	53.8	903		—	—	54.6	910		—	—	53.0	863	
Sept. 11	—	—	54.4	—		—	—	57.1	—		—	—	57.0	—	
Sept. 14	—	—	—	985		—	—	—	926		—	—	—	905	
Sept. 28	—	—	53.5	1010		—	—	58.6	956		—	—	57.5	919	

There was very little difference in the live weight increase of the cattle on the permanent pasture and of those on the temporary pasture. The greatest difference between the two types

of pasture was provided by the wether lambs, which were taken to the plots on the 16th of July. These wethers averaged about 45 lb. and were out of Welsh ewes which had been turned up to the mountain after shearing. The wethers on temporary pasture WW increased from 46 to 58½ lb., and those on OW from 45 to 57½ lb., a gain of 12 lb. in each case. Although the rate of increase was slow in the latter half of September, the lambs did not fall back in condition on either of the temporary pastures. On the permanent pasture the lambs made an increase of 8 lb., and actually lost weight towards the end of September; their weight on the 28th of September was no greater than on the 15th of August. The superiority of the lambs on the temporary pasture was obvious without the use of the weighing machine. This difference between the permanent and temporary pasture is interesting in view of the experience of many flockmasters, who find that their lambs do not thrive well after the middle of August. This lack of thriving which frequently develops towards the end of summer is not due to shortage of grass; in this trial, as is often the case in practice, there was an ample supply of grass, and the cattle on the permanent pasture were increasing in weight at the end of the season at a rate at least equal to that of those on the temporary pasture.

Live weight increase per acre.

The live weight increase per acre from the permanent pasture plots is shown in Table VI.

TABLE VI.

Increase in live weight (lb.) per acre, 1931.

Class of stock.	*Permanent pasture.*	*Temporary pasture.*	
		Plot WW.	*Plot OW.*
Ewes ...	23.7	60.7	48.4
Lambs ...	102.5	142.5	107.6
Wethers ...	41.8	76.0	56.4
Heifers ...	172.0	217.0	192.5
Total ...	340.0	496.2	404.9

Thus there was a live weight increase of 340 lb. per acre from the permanent pasture, 496 lb. from the temporary pasture in which wild white clover had been included, and 405 lb. from the temporary pasture in which no wild white clover had been sown Placing the live weight increase of the permanent pasture at 100,

that of temporary pasture WW becomes 146, and that of OW 119. The greater production from the temporary pastures is accounted for by their greater stock carrying capacity, and also by the fact that the ewes and wethers on the temporary pastures made greater average gains in weight. Thus, while the difference between the two temporary pastures was due mostly to a difference in their stock carrying capacity, the difference between the temporary and the permanent pasture was caused not only by the greater stock holding capacity of the former, but also by the greater individual increases in weight made by the ewes and wethers grazing this pasture. Martin Jones (3) found that from the middle of June to the end of August the live weight increase from a good permanent pasture amounted to 3.1 lb. per acre per day, while the increase from a temporary pasture amounted to 4.5 lb., a difference of approximately 45 per cent. in favour of the latter. In the Bangor trial the temporary pasture was not of special quality, being representative of that found at the farm; the only manuring carried out on this pasture since its formation was a light dressing of farmyard manure in the winter of 1928-29, between the hay crops taken in the first two years.

Conclusions.

(*a*) A 7 acre field of good, permanent pasture was compared with a 4 acre temporary pasture in which wild white clover had been included when seeding down, and with a temporary pasture in which none of this constituent had been included. The live-weight increase from the wild white temporary pasture in its fourth year was 46 per cent. greater, and that from the other temporary pasture 18 per cent. greater than that from the permanent pasture.

(*b*) The increased production from the temporary pastures was due to a greater stock carrying capacity, and also to the ewes and wethers thriving better on these pastures than on the permanent pastures. The wethers on the permanent pasture made no gain in live weight from the middle of August to the end of September; those on the temporary pastures increased by over 4 lb. per head during this period.

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FURTHER TESTS OF NATIONALITY AND STRAIN IN GRASSES.

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Since 1924 plots have been laid down each year at the University College Farm, Bangor, to test the persistency and yield of grass species of various origins. It is proposed here to record some of the results obtained to date from different strains and nationalities which have been sown in competition in seeds mixtures in the field and under conditions of hard grazing, especially in the spring period.

(1) Cae Bryn Gwylan Pellaf.

These plots were laid down in 1925, and a detailed botanical examination was made of the sward in the Spring of 1928. Those results were published in Volume V of this *Journal* in 1929, and for details of lay-out and management the reader is referred to that publication.

There were in all twenty-four plots, twelve of which were controls, throughout the series a control alternating with an experimental plot that contained but one variant from the control. The following table gives the seeding for the control plots, and the basal seeding for the experimental plots.

TABLE I.

	lb. per acre.
Italian ryegrass ...	4 Sutton's.
Perennial ryegrass ...	12 McGill & Smith's ordinary Ayrshire.
Cocksfoot ...	6 Garton's Danish.
Timothy ...	5 Garton's U.S.A.
Meadow fescue ...	5 Garton's U.S.A.
Rough-stalked meadow grass ...	½ Sutton's.
Crested dogstail ...	½ Sutton's.
Late flowering red clover ...	3 Sutton's.
Wild white clover ...	1 Sutton's.

The elements that varied from plot to plot were perennial rye-grass, cocksfoot, timothy and meadow fescue, and it will be seen that a fair seeding of each of these was given so as to allow them from the start a good chance of establishment. Likewise a fair seeding of wild white clover was given so that whatever merit

any grass might possess could be assessed alongside of a good plant of wild white clover—the *sine qua non* of good temporary pastures to-day. The variant in each respective experimental plot was substituted at the same rate of seeding as the commercial form it displaced from the control.

The land was mown for hay in 1926 and 1927. The plots were examined in April in 1928 and the percentage by weight of the main ingredients ascertained.

A second botanical examination of the plots was made from late October to early December, 1930, by the same method as in 1928, the ley being then in its sixth year.

The results of both analyses are given in Table II. For conciseness the figures for the non-variant elements and for volunteer species that were not sown in the mixture are grouped together either as Miscellaneous Grasses or as Miscellaneous Non-gramineous species. Specific representation in the table is shown only for perennial rye-grass, cocksfoot, timothy and meadow fescue—the variant elements—and for wild white clover. It will be noted also that there are two lines of figures for each species or group in the table. The upper row in each case gives the figures for the April, 1928, examination, while the lower indicates the percentage representation as revealed by the late autumn examination in 1930. The variant from column to column is in italics. The twelve plots of variants (even numbers of the series 2-24) are included. Three only of the controls (numbers 8, 11, and 19 of the broken odd series 1-23) at representative distances, have been included in the table.

Consideration of results.

Before passing to a consideration of the variation in persistency to be found within different strains and nationalities of the main grass species included, it is obvious that very material deterioration of the swards has taken place from the fourth to the sixth year of the ley (*i.e.*, from spring, 1928, to autumn, 1930).

The wild white clover figures at the times of the two samplings are not the best indices of this, for the representation of this plant fluctuates materially with the season. The figures throughout are substantially lower for 1930 than they were for 1928. The discrepancy is in part, however, accounted for by the dormancy that characterises this plant with the approach of winter as compared to the quickening of its vegetative parts in spring. The 1928 figures taken in spring tend to favour the

TABLE II.—Percentage Composition by weight.

	Year.	Plot 2. Sutton's indigenous perennial ryegrass.	Plot 3. Control.	Plot 4. Garton's indigenous perennial ryegrass.	Plot 6. McGill & Smith's indigenous ryegrass.	Plot 8. Svalöf Victoria ryegrass.	Plot 10. Garton's English cocksfoot.	Plot 11. Control.	Plot 12. Garton's grazing N.Z. cocksfoot.	Plot 14. Sutton's indig. cocksfoot.	Plot 16. McGill & Smith's N.Z. cocksfoot.	Plot 18. McGill & Smith's Scot. cocksfoot.	Plot 19. Control.	Plot 20. Sutton's American timothy.	Plot 22. Sutton's Scot. grazing timothy.	Plot 24. Garton's Eng. grazing meadow fescue.
Perennial ryegrass ...	'28	23.1	13.5	26.7	14.2	7.3	8.3	10.9	8.4	11.8	9.8	9.4	11.3	9.7	13.2	9.8
	'30	40.7	11.7	29.6	11.9	10.5	...	8.1	...	...	...	...	4.7	...	...	...
Cocksfoot ...	'28	2.3	1.9	1.2	1.5	1.8	3.5	2.5	14.7	12.5	16.1	6.2	2.5	2.3	3.0	3.1
	'30	...	.3	...	...	...	.4	Tra	.7	4.0	13.8	.2	.3	...	...	...
Timothy ...	'28	1.7	4.9	2.8	4.0	3.2	2.1	2.9	5.6	4.7	4.1	4.4	4.4	4.6	5.8	3.9
	'30	...	.3	...	...	...	...	Tra	...	...	...	...	...	...	.2	...
Meadow fescue ...	'28	.2	.1	.1	Tra	...	.7	.3	.4	.5	Tra	.6	.4	.2	.5	.5
	'30	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Wild white clover ...	'28	26.1	28.5	24.0	20.0	25.4	19.5	17.7	14.2	16.3	10.8	14.2	18.2	20.0	11.4	18.9
	'30	17.9	14.4	30.2	13.1	14.9	11.8	10.4	9.4	7.6	8.9	9.9	9.1	9.1	9.6	8.8
Miscellaneous grasses ...	'28	31.1	22.7	20.8	23.0	25.2	27.5	31.8	31.6	27.6	29.3	35.6	31.7	24.8	29.9	26.3
	'30	23.5	30.6	23.5	29.4	40.5	56.1	42.2	59.2	62.9	61.0	73.8	71.4	68.6	74.5	73.8
Miscellaneous non-gramineous species	'28	15.7	28.3	24.4	37.4	37.0	38.4	34.1	25.1	26.6	29.6	29.6	31.5	38.8	36.5	37.4
	'30	17.8	42.8	16.6	45.5	34.0	31.8	39.3	30.6	25.6	16.2	16.1	14.4	22.4	15.8	17.4

representation of this species as compared with the 1930 figures read in the late autumn.

No such explanation can, however, be extended to account for the increase of unsown species that followed between 1928 and 1930. The miscellaneous grasses (in decreasing order of representation at the time of the 1930 analysis—crested dogstail, bent grass, Yorkshire fog, rough-stalked meadow grass and sweet vernal) with the exception of plot 2, have increased materially. In some cases the three growing seasons between the spring of 1928 and autumn of 1930 have seen their representation more than double what it was when the first analysis was made. In some cases over two-thirds of the vegetation at the time of the second analysis consisted of volunteer and undesirable grass species. The figures bear out the general impression one gets of the obvious decline that follows the use of commercial herbage species especially from the third to the sixth year of the life of a ley. Where but one truly persistent species has been included in the initial seeding, as the ryegrass elements in plots 2 and 4, the value of such elements in arresting decline becomes strikingly obvious. Not only have these rye-grasses actually gained ground in the interval, but the element wild white clover, whose welfare in sown swards has time and again been proved to be closely linked with the destiny of perennial rye-grass, has advanced collaterally with it. Thereby they have jointly served in checking the establishment of bent grass and Yorkshire fog and arrested the rapid decline of the sward, so patent in their absence.

The increased representation of miscellaneous grasses, shown by a steady drift from left to right in the figures for 1930 for miscellaneous grasses in Table II, *i.e.*, as we advance from plot 2 towards plot 24, may seem to represent a geographical tendency in soil conditions, etc. It can scarcely be so, however, as there is no such parallel drift in the figures for the earlier analysis (1928). We would suggest that it more nearly represents the decline that set in with the passing out of other sown species which up to 1928 rendered the decline inoperative or delayed its full operation plot by plot as we advance from plot 2 to 24. This opinion is warranted by the fact that persistency amongst the species tested waned in succession from the rye-grasses, through the cocksfoots and timothies in the order mentioned, a sequence that is identical with the location of these species in succession from left to right and from plot 2 to 24 in the field.

Perennial rye-grass strains.

TABLE III.

	Percentage by weight.	
	1928	*1930*
Ordinary Ayrshire (control) ...	11.9	8.2
Sutton's indigenous perennial rye-grass ...	23.1	40.7
Garton's indigenous perennial rye-grass ...	26.7	29.6
McGill & Smith's indigenous rye-grass ...	14.2	11.9
Svalöf Victoria ryegrass ...	7.2	10.5

It is gratifying to note that as the ley has aged, passing through the critical period in its history (*i.e.*, passing from its third year to its sixth) the representation of the indigenous types of perennial rye-grass has increased considerably with the exception of McGill and Smith's strain. Prime place goes to Sutton's strain, which has advanced from 28 per cent. to over 40 per cent. representation, displacing Garton's strain, which meanwhile enhanced its position also from 27 per cent. to 30 per cent. representation. Both of these have proved eminently successful strains. McGill and Smith's strain has lost ground slightly, but still excels over the figure for the average of the three controls. It is also worthy of notice that Svalöf Victoria rye-grass, which in 1928 did not warrant its inclusion to displace the commercial type, has advanced slightly meanwhile and figured more largely in the sward than did the commercial type in 1930.

It remains to add that the wild white clover population of all these plots where the rye-grass element has persisted and flourished stands considerably higher than it does elsewhere in the series, being highest on the plot of Garton's indigenous rye-grass. Likewise the figures for volunteer grasses and miscellaneous plants (unsown) have been materially checked by the successful establishment of persistent rye-grass strains, a fact of immense significance to the economy of grassland farming generally and to the productiveness and usefulness of temporary leys of this kind whose longevity is mostly determined by the rate at which they decline.

Cocksfoot strains and nationalities.

TABLE IV.

	Per cent. by weight.	
	1928	*1930*
Garton's Danish Cocksfoot (control) ...	2.3	.2
Garton's mowing English cocksfoot ...	3.5	.4
Garton's grazing New Zealand cocksfoot ...	14.7	.7
Sutton's indigenous cocksfoot ...	12.5	4.0
McGill & Smith's wild N.Z. grazing cocksfoot	16.1	13.8
McGill & Smith's mowing Scottish cocksfoot	6.2	.2

The obvious difference observed in the spring of 1928 between the grazing strains and the mowing strains has not been maintained into the autumn of 1930 except in the case of McGill and Smith's wild New Zealand grazing cocksfoot. It is only on this spot that the representation has been maintained at a figure approaching the figure at the time of the earlier examination. Sutton's indigenous cocksfoot has resisted deterioration slightly better than the remaining strains. Elsewhere the figures have shrunk to a fraction of a percentage, proving that they have not been able to withstand the rigorous conditions of heavy and continuous grazing.

Timothy nationalities.

TABLE V.

	Per cent. by weight.	
	1928	*1930*
Garton's U.S.A. timothy (control) ...	4.0	Trace
Sutton's American mowing timothy ...	4.6	—
Sutton's Scottish grazing timothy ...	5.8	.2

There is no comment necessary here. All strains alike have failed to withstand the rigour of the trial. This is not surprising, for timothy thrives only under mowing conditions and, as it is not biologically endowed with any feature that favours its spread under conditions of severe inter-specific competition, being a spot bound plant it fails.

Meadow fescue.

There were but traces of the two strains of meadow fescue included in the trial left in the sward at the time of the earlier

analysis. No trace of either (U.S.A. meadow fescue, and Garton's English grazing meadow fescue) remained by the autumn of 1930, though a careful search of the whole plots, and outside the samples drawn for analysis, was made at the time. In this connection the high incidence of a pedigree strain of tall fescue from the Plant Breeding Station at Aberystwyth, in another trial, and recorded here later, is of particular significance.

(2) Cae Bryn Meddyg.

This field was laid down in 1924 under oats after roots. Four plots were laid down in seven yard strips the length of the field. The seeding of plot 1, which follows, is the basal mixture for the bulk of the field. They are all from commercial stocks, and contain no seeds of indigenous stocks.

Plot 1. Basal mixture in lb. per acre.

Italian ryegrass	6
Perennial ryegrass	12
Cocksfoot	5
Timothy	2
Crested dogstail	½
Vale of Clwyd red clover	3½
Essex broad red clover	2
Wild white clover	¾

In the three remaining plots were accommodated the small stocks of seeds that were at the time available from selections at the Welsh Plant Breeding Station at Aberystwyth. They differ respectively from the basal mixture used on plot 1 as follows :—

Plot 2.—Welsh Plant Breeding Station indigenous cocksfoot (Bc/225/1) substituted for the commercial form at the same rate.

TABLE VI.

Percentage composition by weight.

	Plot 1.	*Plot 2.*	*Plot 3.*	*Plot 4.*
Perennial ryegrass ...	20.9	9.1	19.6	25.5
Cocksfoot ...	5.8	37.5	2.2	9.5
Crested dogstail ...	9.8	11.5	10.7	7.5
Timothy ...	1.4	.4	1.9	.5
Wild white clover ...	32.8	18.9	22.5	24.4
Miscellaneous grasses	25.7	22.2	24.4	22.4
Miscellaneous non-gramineous species	4.2	5.5	6.5	10.3
Tall fescue ...	...	...	12.3	...

Plot 3.—Indigenous tall fescue (Bn/19/1) from the Welsh Plant Breeding Station has been added to the basal mixture.

Plot 4.—Welsh Plant Breeding Station indigenous perennial rye-grass (Ba/25/2) has been substituted for the commercial element at the same rate.

The plots were sampled and an analysis made of their botanical composition by weight in January and February of 1931. The results are shown in Table VI.

In the above table the variant element in each plot is in italics. The miscellaneous grasses grouped together were comprised of rough stalked meadow grass, Yorkshire fog, bent grass and bulbous oat grass in descending order. This meadow grass is commonly included in all mixtures at the farm, and, though it has proved the most active pioneer species, the value of its omission is doubtful in view of the high representation of crested dogstail on all plots in its absence. It is, however, noteworthy that the high establishment of crested dogstail, though the presence of its flowering stalks in late summer gives to the grazed sward the false appearance of being heavily infested with bent, has so effectively checked the development of true bent grass that the field, now in its eighth season, retains a wonderfully clean sole of palatable herbage.

The indigenous cocksfoot element on plot 2 has held the ground surprisingly well, even against heavy grazing by sheep throughout the seasons. This plot by its colouring has stood out from the rest, and, despite continued grazing in the critical months of spring, it persists where the commercial strain of this grass on the other plots has almost disappeared. It should be noted, however, that its success has lowered the representation of wild white clover on this plot as it has depressed the rye-grass element.

It is gratifying to note also that seven years from seeding indigenous tall fescue contributes considerably to the sward without having depressed unduly the figures for the other excellent species. Having regard to the hard grazing conditions that rule over the pastures of the College Farm, we have for some years been forced to omit this species from our normal seeds mixtures. It is to be hoped that with the production of more abundant supplies of indigenous types of the grass it will, in future, be possible to incorporate it in mixtures for our conditions where the average commercial form of it has hitherto failed to hold the ground.

Indigenous perennial rye-grass on plot 4 is slightly superior in representation to the best of the commercial form on the other plots. The difference is not outstanding, but the truly surprising fact is that, with the exception of plot 2, where rye-grass has suffered appreciably from competition with indigenous cocksfoot, the rye-grass element has persisted throughout the series much better than is normally expected of it under the conditions that prevail in North Wales.

The trial is but a minor one, but again it serves to demonstrate what is already definitely established, viz., that for grazing swards persistency is most surely attained by the adoption of indigenous strains. The degree of their superiority is governed by the conditions that pertain; the more severe the grazing, and the more decline threatens, the more imperative it is that indigenous strains be adopted.

NEW VARIETIES OF WHITE WINTER OATS.

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Although the production of improved varieties for spring cultivation constitutes the major part of the work in oat breeding investigations at the Station it nevertheless happens that of the crosses made during the first year of experimentation those designed for the production of new hardy white-grained winter oats proved to be the most successful, and consequently segregates from these were the first to be brought to a fixed breeding state and, therefore, to enter trials for yield and other varietal characteristics.

The belief that winter oats might, with advantage to the farmer, take a somewhat more important place in the economy of cereal production on farms in the Principality than they do at the present time received support from trials conducted at the Station during the years 1921 and 1922.[1] These trials, which were designed to compare relative yields of winter and spring varieties in straw and grain, suggest very clearly some advantages which can be obtained from the devotion of a certain portion of the oat area to a winter-sown variety. The data are reproduced in Table I and may be briefly considered here.

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[1] Preliminary Investigations with Oats. *Welsh Plant Breeding Station Bulletin*, Series C, No. 8, 1928.

TABLE I.

To compare the yields of autumn with spring sown oats for the two harvest years 1921 and 1922.

	Grain wt. per 1000; gm.	*Grain. Cwt. per acre.*	*Straw. Cwt. per acre.*	*Percentage of husk in grain.*
1921. AUTUMN SOWN.				
Average of five varieties ...	31.2	30.8	64.6	25
Best (Winter Turf)	—	37.2	72.0	—
SPRING SOWN.				
Average of five varieties ...	28.0	14.0	20.2	28
Best (Victory) ...	—	16.1	24.2	—
1922. AUTUMN SOWN.				
Average of five varieties ...	33.7	27.9	45.2	23
Best (Bountiful) ...	—	28.8	51.8	—
SPRING SOWN.				
Average of five varieties ...	34.0	28.5	34.0	25
Best (Crown) ...	—	32.1	34.8	—

In the year 1921, which was characterised by a very dry summer, the average grain yield of the five winter varieties (as seen from Table I) was slightly more than twice that of the average of five spring varieties, and the average straw yield three times as much. In the year following, in which conditions were extremely favourable to spring-sown varieties, the winter varieties gave grain yields approximately equal to the average of the spring varieties, and in addition about 50 per cent. more straw (Season 1922, Table I). These results covering two seasons differing widely meteorologically indicate the capacity of winter varieties to withstand conditions of drought occurring during the summer months.

Apart from the greater bulk of produce frequently available through the use of winter varieties there are other advantages to be gained from sowing a certain proportion of the oat area in the autumn. Pressure of work in the spring is considerably eased, and harvesting of the crop takes place earlier and generally under more favourable weather conditions, an important consideration in relation to Welsh agriculture. On the other hand there are the disadvantages of risks due to lodging when such varieties as Black and Grey Winter are sown, and of winter-killing when a choice of a white-grained variety is made from existing tested varieties. These disadvantages, however, are due to the general unsatisfactory character of the varieties.

and should disappear as better and improved kinds are introduced into practice. In the past, comparatively little serious effort has been made to improve existing sorts or to introduce suitable and superior new strains through crossing and selection. Such white-grained varieties as have in the past been introduced have not proved themselves to possess the necessary degree of winter-hardiness. There exists, therefore, ample scope for the breeder in the provision of better winter varieties combining, in a satisfactory degree, winter-hardiness, white colour of grain and marked resistance to lodging, and for Welsh conditions, resistance to a high autumn and winter rainfall. White colour of grain seems desirable as it commands a higher market value relative to either black or grey-grained oats.

In autumn-sown varieties risk of loss through winter-killing is generally much reduced through sowing at the time of the year most appropriate to the district, late sowing in general being found to be least reliable and to involve the greatest risk. The most favourable time varies slightly from district to district. Under conditions prevailing at Aberystwyth sowing during about the third week of September, conditions being favourable, has met with greatest success on the score of consistency in freedom from losses due to winter-killing. Sowing at this time enables the young plants to make efficient root growth before the wet conditions, which frequently occur towards the end of October or beginning of November, set in.

Corroborative evidence of the importance of early sowing is afforded by some unpublished data provided by Mr. Ll. Iorwerth Jones,[2] which relate to certain phenological investigations conducted by him on a very exposed piece of land at Frongoch (the farm of the Welsh Plant Breeding Station).

In these investigations he found in the three years 1928-31 that in the hard winter of 1928-9 mid-October sowings of Grey Winter were killed off by January, while mid-September sowings survived the early cold period and were only eventually killed off by the unusually severe weather experienced in February and March of that season. In the milder winter of 1929-30 September sowings made good early growth, while mid-October sown plots were weak and badly checked by continuous wet weather. Many plants of the October sowing died off before reaching the four-leaf stage and only a thin and poor crop was ultimately obtained. The September sown plots, however, gave

[2] Concerned with grassland investigations at the Welsh Plant Breeding Station.

good yields. Differences of a like character were obtained in the 1930-1 season.

Similar reactions were observed in wheat by Janssen[3] in America. He found that winter-killing following " heaving " of the plants due to alternate frost and thaw was largely influenced by root development which in turn depended upon date of sowing. Early seeding produced better autumn root development, and less winter-killing followed. Broadcast plots generally suffered worse than drilled plots, while survival rate was highest on relatively dry soils. Mid-September sowings gave least winter-killing.

On the other hand, however, and where winter-killing is not a factor to be seriously reckoned with, too early sowing frequently leads to high tillering and over-dense establishments, which under good soil and favourable weather conditions frequently fail to give the highest grain yields.

It is the object of the present paper firstly, to give a brief account of the main facts concerned in the breeding of two new white-grained varieties of winter oats, and secondly, to present data upon which their relative merits compared with existing commercial varieties may be judged.

The Crossing, Selecting, and Fixing of the new varieties.

To trace very briefly the breeding history of these two new varieties it is necessary to go back twelve years to the summer of 1920, when a cross was made between the varieties Grey Winter and Kyko.[4]

From the progeny of this cross it was hoped to be able to select and fix strains which combined in one and the same variety the winter-hardiness of the Grey parent with the white colour of grain and reasonably good strength of straw of the Kyko variety, and to obtain these without loss of yielding capacity and other desirable characters.

Three seeds were obtained from the cross and these were sown singly in pots in the spring of 1920 and later planted out in a birdproof cage with liberal spacing to permit free development of the plants. In the following season the seeds from these three plants were sown in boxes and the seedlings later planted out as

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[3] Janssen, G. Date of seeding wheat and winter hardiness. *Journ. Amer. Soc. Agron.*, XXI, 1929.

[4] Kyko is a spring-sown oat little known in this country. It was obtained by the Welsh Plant Breeding Station from Dr. Alun Roberts, University College of North Wales, Bangor, who received it from Kew. It is reputed to have come originally from Cyprus. Of our spring varieties it most closely resembles Yielder, but its grain is distinctly smaller.

spaced single plants. From amongst this generation only those plants with white grain of good or reasonably good quality were selected to be carried forward into the next season; the remainder which were either grey-grained or whites of inferior quality, were discarded. This meant the immediate elimination of nearly 2,000 plants, leaving only 185 with which to proceed to the next generation. From these in the next year a weighed amount of seed of each was sown on a "plant-to-row" basis, and throughout the growing period close attention was paid to capacity to tiller, leaf width, general habit of growth and resistance to lodging. At harvest time it was possible to discard completely the progenies of a large number of plant-rows, while from the remainder a total of 867 single heads were selected to be continued into the next generation. Of these selected heads 195 were sown in separate head-rows in the autumn of the same year, and the remainder on a similar head-to-row basis in the spring.

The sowing of the autumn-sown series was carried out on November 14; this was late for the district, but on that account was all the more effective in aiding the diagnosis of non-winter-hardy types. Many rows were thin and brairded unevenly, while others established themselves well. By comparison with rows of the check variety Grey Winter, which was introduced at intervals between the several head-row selections, estimates of the relative winter-hardiness of the individual head-rows were made and adopted as a basis for further selection or elimination.

The term "winter-hardiness" as employed in connection with the present breeding work needs some qualification. The general run of meteorological conditions prevailing in west and mid-Wales during late autumn and the winter months generally is a combination of strong winds, high rainfall and moderately low temperatures frequently and irregularly interspersed with intervals of relatively mild weather. Resistance to such conditions is therefore probably of a somewhat different character from resistance to prolonged periods of relatively dry weather with low or very low temperatures. In the early spring, conditions frequently are drier and when active growth is about to begin, killing-off may sometimes take place through a combination of drying winds, frosty nights and bright sunny days. It is therefore with reference to resistance, or relative resistance, to the sum total of these conditions that the term "winter-hardiness" is used in the present paper. Those selections which emerge through the winter and early spring conditions with the least injury or thinning-out are accordingly referred to as the most "winter-hardy" forms.

On this basis of evaluation it was observed that certain groups of the head-rows grown in the 1923-4 season had survived the winter better than others; these were traceable to heads taken from particular individual plant-rows of the preceding year. This pointed to the occurrence of greater inherent winter-hardiness in certain progenies as compared with others. Derivatives re-traceable to rows from the second generation plants numbered 54, 58, 113, 129, 179, 180, 224, 480 and 487 respectively were the most uniformly hardy. Eliminations of many non-winter-hardy head-row progenies were made in this season, while only the more generally winter-hardy groups were carried forward another year.

In the season 1924-5 sowing was carried out on October 25. The best rows of the preceding season were not on this occasion re-selected on a single-head basis, but the seed from each row was separately bulked and from the latter weighed quantities of seed were taken for sowing duplicate small two-drill beds. To these autumn-sown lots were added a number of selections taken from the spring-sown series.

The winter of 1924-5 was extremely helpful to the study of winter-hardiness. No prolonged spells of low temperature were experienced, but the extremely wet and relatively severe conditions which prevailed caused a large amount of differential winter-killing to take place. Several strains which were outstanding in the autumn-sown series of the preceding season again showed good winter-hardiness and successfully maintained a reasonably dense growth throughout the winter period. In this respect derivatives traceable to the second generation plants 54, 58, 129, 179 and 224 were again the most satisfactory. Selections from plants 19 and 55 added from the spring-sown series also gave good establishments. Other rows were less uniform or less generally hardy. At the end of the 1925 season only twenty-two of the 124 groups of selections were considered to be of sufficient promise to warrant further study, and from this restricted number 409 heads were taken, selected mainly from the derivatives of 19, 54, 55, 58, 129, 179 and 224 respectively. The rest of this season's material was harvested and put aside as a reserve supply for future re-selection if necessary.

On September 17 of the same year the 409 selected heads were sown on a head-row basis, interspersed at regular intervals with rows of Grey Winter. These lots were further closely studied in respect of general habit of growth, degree of tillering, freedom from winter-killing, time of heading and ripening, resistance

to lodging and purity to type within the respective rows. Thinning-out, through winter-killing, did not occur to any marked degree in this season, and was least in the head-rows of selections from the 54, 58 and 179 groups of which there were under observation 61, 58 and 55 separate head-row progenies respectively. Observing the head-rows as groups classed according to common ancestry from particular individual second generation plants, it was apparent that the members of a group often possessed certain features in common. Thus in a general way members of the group ultimately derived from the F_2 plant 54 were all highly winter-resistant, and possessed relatively good grain, whereas members of the 58 and 179 groups, while almost equal in winter-hardiness, showed more marked resistance to lodging, but slightly inferior quality of grain. In the 179 group in particular the grain generally was somewhat coarse in the husk. The best grain, both in respect of size and quality and the earliest selections to ripen were found in group 129 which, although possessing a certain degree of winter-hardiness, was inferior in this respect to members of groups 58 and 179. Following examination of the grain of the separate head-rows and consideration of the data collected in the 1925-6 growing season, it was concluded that in respect of fixity of type these several selections possessed a sufficient degree of homozygosity to permit a beginning to be made in the next stage of the work; namely, the development of small bulks of seed from a few specially selected rows to enable yield tests and final field studies to be commenced.

For reasons of space and labour involved it was not possible even if it were desirable immediately to develop all the head-rows and subject them to yield tests; consequently, only a few of what were regarded as the best of the best groups were taken for this purpose. Many of the remaining head-rows were then discarded, while others were continued in duplicate 2-drill beds. At this point, however, we shall discontinue discussion of the latter and confine our attention to those lots singled out for initial and immediate yield tests.

The Determinations and Comparisons of Grain and Straw Yields.

Although in the yield testing phase of the breeding work we are mainly concerned with yields or relative yields, it is not solely upon this criterion that the further evaluations are made. Up to this stage observations have been based upon single rows or very small beds of material which have been repeatedly changing from year to year. The general fixity of the strains,

the larger plots and the closer approach to field conditions, which characterize the yield trial stage, furnish a much desired opportunity for observing the re-actions of the strains under conditions approximating to farm practice.

Of the 409 head-rows grown in the season 1925-6, nine were selected for inclusion in the preliminary yield trial tests. These head-rows carried the Station reference numerals 3/1/3/54, 5/1/3/54, 1/2/3/54, 6/3/3/54, 3/3/3/58, 7/2/2/129, 25/1/2/179, 2/2/5/179 and 18/1/10/224 respectively. The quantities of seed available from the single-head rows were inadequate for an immediate field trial, but rapid multiplication was effected by growing the available seed as spaced single grains. In this way sufficient seed was obtained to enable the laying down of an initial trial in the form of four-times replicated 1/200th acre plots in the succeeding year.

Two sets of tiller counts were made during 1927, when the selections were grown on a spaced-grain basis. The first count was carried out on April 25, when the plants were approaching their maximum degree of tillering, and the second at the time of harvesting, when it agreed with the number of ear-bearing shoots.[5] The average figures obtained for the single beds of each selection were as follows :—

		April 25.		*August 16.*
3 1 3 54	...	9.3	...	3.7
5/1 3 54	...	13.3	...	4.2
1 2 3 54	...	12.7	...	3.8
6 3 3 54	...	11.1	...	4.8
3 3 3 58	...	14.5	...	5.0
25/1 2 179	...	12.1	...	3.8
7/2 2 129	...	6.3	...	2.8
2/2 5 179	...	4.9	...	2.9
18 1 10 224	...	6.1	...	3.2

These figures show a wide range in numbers, especially in the April counts. They readily divide themselves into two main groups (*a*) those with an average of 6.8 tillers per plant or less, and (*b*) those with 9.8 and upwards. In the counts taken at harvest time the differences are reduced, but the two groups remained distinct. The dying-back of the tillers, however, was correspondingly less in the low tillering than in the high tillering group. The extent to which dying-back of the tillers takes place is a feature worthy of note, and is a phenomenon common to

[5] Counts were restricted to determinations of the tillers in rows at six-row intervals throughout each bed and were exclusive of border plants and end rows.

TABLE II.

Summary of average grain yields in ten trials conducted at Frongoch and in the counties during the four seasons 1927-1931.

Year of Trial. Trial Reference and Date of Sowing.	Name or Reference Number of Variety.												
	Grey Winter "check."	3/1/3/54 (S. 81).	3/3/3/58 (S. 82).	1/2/3,54	6/3/3/54	25/1/2/179	2/2/5/179	5/1/3/54	7/2/2/129	*Plentiful.*	*Quite Content.*	*Marvellous.*	*Unique.*
1927–8. Trial 1. (Lower Ridge Field, sown 8/10/27.)													
Cwt. per Acre	19.6	18.6	16.1	22.5	16.1	19.3	19.9	17.8	14.6	11.4	2.1	—	—
Relative to check var.=100	**100.0**	**95.0**	**82.2**	**115.0**	**82.2**	**98.4**	**104.6**	**91.1**	**74.5**	**58.0**	**10.5**	—	—
1928–9. Trial 2. (Gorse Field, sown 5/10/28.)													
Cwt. per Acre	21.8	18.0	17.4	12.8	18.9	14.4	—	—	—	—	—	—	—
Relative to check var.=100	**100.0**	**82.7**	**79.9**	**58.8**	**86.7**	**66.2**	—	—	—	—	—	—	—
1929–30. Trial 3. (Lower Ridge Field, sown 21/9/29.)													
Cwt. per Acre	23.0	24.4	23.3	26.7	24.3	21.9	—	—	—	21.4*	—	21.6*	—
Relative to check var.=100	**100.0**	**106.3**	**101.1**	**116.0**	**105.7**	**95.5**	—	—	—	**93.0**	—	**93.9**	—
1929–30. Trial 4. (Cwm Field, sown 23/9/29.)													
Cwt. per Acre	19.4	25.4	19.3	25.6	24.6	20.1	—	—	—	—	—	—	—
Relative to check var.=100	**100.0**	**131.0**	**99.6**	**132.4**	**127.1**	**103.9**	—	—	—	—	—	—	—
1929–30. Trial 5. (Gorse Field, sown 24/9/29.)													
Cwt. per Acre	18.9	22.9	23.5	21.9	25.1	23.0	—	—	—	—	—	—	—
Relative to check var.=100	**100.0**	**121.4**	**124.3**	**116.0**	**132.9**	**122.0**	—	—	—	—	—	—	—
1929–30. Trial 6. (Covenhope, Hereford, sown 12/10/29.)													
Cwt. per Acre	2[illegible].2	28.6	[illegible]4.2	29.6	30.2	30.3	—	—	—	—	—	—	—
Relative to check var.=100	**100.0**	**123.1**	**147.6**	**127.4**	**130.3**	**130.8**	—	—	—	—	—	—	—
1929–30. Trial 7. (Penwenallt, Cards., sown 21/9/29.)													
Cwt. per Acre	15.7	18.8	19.4	17.9	17.8	16.8	—	—	—	—	—	—	—
Relative to check var.=100	**100.0**	**119.8**	**123.9**	**113.8**	**113.3**	**107.3**	—	—	—	—	—	—	—

All figures are averages of 4, 5 or 6 times replicated plots. Trial 8 figures are omitted as adverse weather prevented the plots being harvested in a satisfactory condition. Figures in heavy type are the relative percentage yields computed on a basis of Grey Winter "check" taken at 100.

* Figures taken from a subsidiary trial.

TABLE II.—Continued.

Year of Trial Trial Reference and Date of Sowing.	Name or Reference Number of Variety.												
	Grey Winter "check."	3/1/3/54 (S. 81).	3/3/3/58 (S. 82).	1/2/3/54	6/3/3/54	25 1/2/179	2 2 5/179	5/1/3/54	7/2/2/129	*Pentiful.*	*Quite Content.*	*Marvellous.*	*Unique.*
1929–30. Trial 8. (Tynycoed, Carms., sown 25/9/29.) No weights taken.	—	—	—	—	—	—	—	—	—	—	—	—	—
Average of 1929–30 Trials.													
Cwt. per Acre	20.1	24.1	24.0	24.4	24.8	22.4	—	—	—	—	—	—	—
Relative to check var.=100	**100.0**	**119.9**	**119.4**	**121.4**	**123.3**	**111.4**	—	—	—	—	—	—	—
1930–1. Trial 9. (Gorse Field, sown 6/10/30.)													
Cwt. per Acre	17.8	22.9	18.9	23.1	—	—	—	—	—	—	—	—	19.8
Relative to check var.=100	**100.0**	**128.7**	**106.5**	**129.8**	—	—	—	—	—	—	—	—	**111.2**
1930–1. Trial 10. (Upper Ridge Field, sown 27/9/30.)													
Cwt. per Acre	9.2	11.2	10.2	11.3	—	—	—	—	—	—	—	—	—
Relative to check var.=100	**100.0**	**112.0**	**110.9**	**122.8**	—	—	—	—	—	—	—	—	—
1930–1. Trial 11. (Gorse Field, sown 12/11/30.)													
Cwt. per Acre	13.7	14.9	16.5	15.2	—	—	—	—	—	—	—	—	—
Relative to check var.=100	**100.0**	**108.6**	**120.7**	**110.9**	—	—	—	—	—	—	—	—	—
Average of 1930–1 Trials.													
Cwt. per Acre	13.5	16.3	15.2	16.5	—	—	—	—	—	—	—	—	—
Relative to check var.=100	**100.0**	**120.7**	**112.6**	**122.2**	—	—	—	—	—	—	—	—	—
Average of all Trials.													
Cwt. per Acre	18.2	20.6	19.9	20.7	22.4	20.8	—	—	—	16.4	2.1	21.6	19.8
Relative to check var.=100	**100.0**	**113.9**	**109.7**	**114.3**	**111.2**	**103.4**	—	—	—	**75.5**	**10.5**	**93.9**	**111.2**

All figures are averages of 4, 5 or 6 times replicated plots. Trial 8 figures are omitted as adverse weather prevented the plots being harvested in a satisfactory condition. Figures in heavy type are the relative percentage yields computed on a basis of Grey Winter "check" taken at 100.

* Figures taken from a subsidiary trial.

many varieties of winter-sown cereals. Notes made in subsequent seasons showed the low-tillering group to be, in general, less winter-hardy than members of the high-tillering group.

The 1927-28 Yield Trials.

The average grain yields produced in the 1927-8 trial are shown in conjunction with other yield trial data in Table II.

Only eight of the nine selections were tested in this trial—18/1/10/224 being excluded owing to certain undesirable straw characters which appeared in the spaced plants the preceding year. Two selections, 1/2/8/54 and 2/2/5/179, have given yields slightly higher than the check variety Grey Winter,[6] and three, 8/1/8/54, 5/1/8/54, and 25/1/2/179 respectively, yields which, although lower than "check", are within the limits of error of the trial, and, therefore, not necessarily significantly different. The lowest, namely, 7/2/2/129, with yield equal to 74.5 per cent. of "check" was, however, markedly superior to the commercial white-grained varieties Plentiful and Quite Content, which gave yields of 58.0 and 10.5 respectively compared with the check variety at 100. The 7/2/2/129 selection was the earliest to ripen and possessed the best grain of the eight segregate selections included in the trial. The winter of 1927-8 was one of more than average severity, particularly in the early part, and much winter-killing appeared in various parts of the plots, particularly in the wetter areas and on that account some selections were affected slightly more disadvantageously than others.

On the basis of the first year's trial the behaviour of most of the new strains relative to Grey Winter and to Plentiful, the most hardy white winter oats then on the market, was on the whole satisfactory.

At the end of the season the harvested seed was divided into two lots, part being set aside for growing small seed stocks and part used for the continuation of yield trials.

The 1928-29 Trials.

In the 1928-9 season Trial 2 was laid down. Observation plots of bulked seed from selected members of the 54, 58, 129 and 179 groups were also grown in single 1/16th acre plots at two county centres, one in Breconshire and the other on the Radnorshire-Herefordshire border. These latter were sown simply for general observation purposes.

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[6] The ordinary variety Grey Winter has been incorporated in all the segregate yield trials as a control or "check" variety wherewith to compute the relative values of the new segregate selections.

The 1928-9 season, which was distinguished by a period of intensely cold and dry weather extending from the middle of February to about the first week of March, gave rise to a good deal of winter-killing. All the plots in Trial 2, including those of Grey Winter, were considerably thinned-out during this period; selections 2/2/5/179, 7/2/2/129 suffered very badly, and others to a somewhat less degree. In spite of the severe winter-killing, later improvement in the weather brought about a reasonably good recovery and the grain yields of Grey Winter in this trial, as will be seen from Table II, were well up to the average, compared with other seasons.[7] Owing to lack of space, Grey Winter was the only commercial variety grown in Trial 2. Relative to Grey Winter the selections in this season all present rather lower yields; 3/1/3/54, 3/3/3/58 and 6/3/3/54 compare least unfavourably, while 25/1/2/179 and especially 1/2/3/54 occupy unexpectedly low positions, compared with their behaviour in the preceding year. Having in mind, however, the general devastation which occurred in many parts of the country amongst autumn-sown white-grained winter varieties of oats in this season, the positions held by the three best selections with yields of approximately 17½, 18 and 19 cwt. per acre, are, on the whole, good, although falling short of the Grey Winter level.

On the score of resistance to lodging, all five selections easily surpassed the Grey variety, 3/3/3/58 being particularly outstanding in this respect (Fig. 3).

Winter-killing in the small seed stock plots alongside Trial 2 was of much the same order as that in the trial plots. Least injury was suffered by 3/1/3/54, while 3/3/3/58 suffered slightly more, but recovered better up to the time of harvest.

The observation plots in Breconshire withstood the unusual climatic conditions very well. Plot 129 thinned-out most, 179 rather less, while apart from small isolated areas relatively little winter-killing took place in plots 54 and 58. Final crops, especially in the two latter strains, were good.

The corresponding plots on the Herefordshire farm conform in general to the behaviour noted in Breconshire, but being sown at a much later date considerably more winter-killing took place. Plots 54 and 58 exhibited relatively least injury and made moderately good recovery, but 179 and particularly 129, suffered badly and continued to remain thin and patchy crops right up to the time of harvest.

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[7] Yields were not taken from the selections 2/2/5/179 and 7/2/2/129 owing to their unsatisfactory winter-hardiness and thin stands, while 5/1/3/54 was discontinued owing to its marked tendency to lodge.

After consideration of the two seasons trials it was decided to concentrate mainly on five selections, namely, 8/1/8/54, 3/8/8/58, 1/2/8/54, 6/8/8/54 and 25/1/2/179, and to submit these to very extended tests in the next season.

The 1929-30 Trials.

Six trials were laid down in 1929-30; three (Trials 3, 4 and 5) at Frongoch, and three (Trials 6, 7 and 8) in the counties of Hereford, Cardigan and Carmarthen respectively. In addition, in the first mentioned county, acre strips of 54, 58 and 179 were sown on separate farms with seed from the observation plots of the preceding year in order to collect more comprehensive data on the important matter of winter-hardiness.

Weather conditions during the 1929-30 season were relatively mild. They were, however, sufficiently severe to cause a marked degree of winter-killing in members of a subsidiary trial, especially in the variety Marvellous, to a less degree in Plentiful, and to a slight extent in 25/1/2/179 included in the main trial (Figs. 1 and 2).

Apart from 1/2/8/54, which this year suffered relatively little injury, all lots in the main trial remained in the same relative order of merit in respect of winter-hardiness as in the preceding season. Members of the "54" group (8/1/8/54, 6/8/8/54, 1/2/8/54) were most resistant. followed closely by 8/8/8/58 and 25/1/2/179. In the "54" and "58" selections no significant winter-killing was apparent in any of the six trials in this season.

Actual and relative grain yields for the separate trials are shown in Table II and in all instances except two—25/1/2/179 in Trial 3, and 8/8/8/58 in Trial 4—the selections are markedly superior to the check variety Grey Winter and also to Plentiful and Marvellous.[8] Lodging was severe in Trials 5, 6 and 8, Grey Winter being affected most, the "54" group rather less, 25/1/2/179 still less, while 8/8/8/58 stood up extremely well almost throughout the whole series. The effect of this upon grain production is patent in Trial 6, where the grain yields of 8/8/8/58 and 25/1/2/179 are 147.6 and 130.8 respectively, compared with Grey Winter at 100. The better grain-filling which occurred in 8/8/8/58 is seen to be reflected in its relatively low percentage of husk in this trial as compared with its husk percentage in Trial 9 (Table VI).

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[8] The figures for Plentiful and Marvellous are taken from the best of three subsidiary trials, in two of which Marvellous was almost a complete failure.

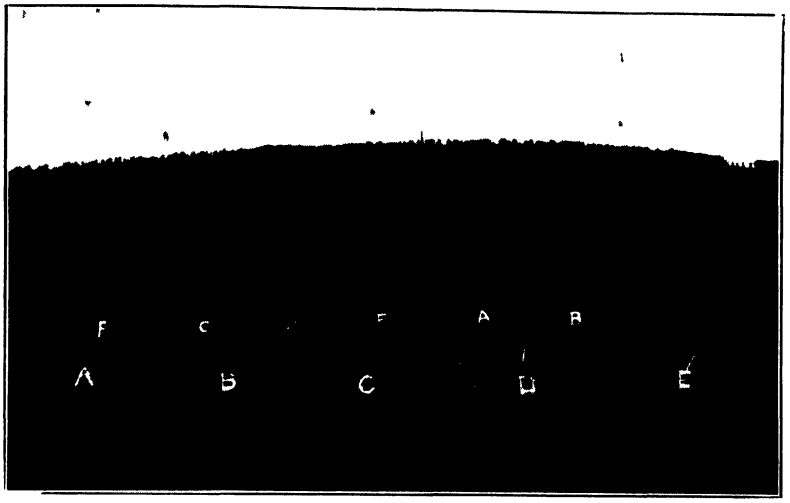

FIG. 1.

Yield trial plots (Gorse Field), 1929-30, photographed April 15, 1930, showing relative resistance to winter-killing.
A—2/2/5/179, B—7/2/2/129, C—Plentiful, D—1/2/3/54, E—Marvellous, F—Grey Winter.
The plots lie immediately above their respective symbols.

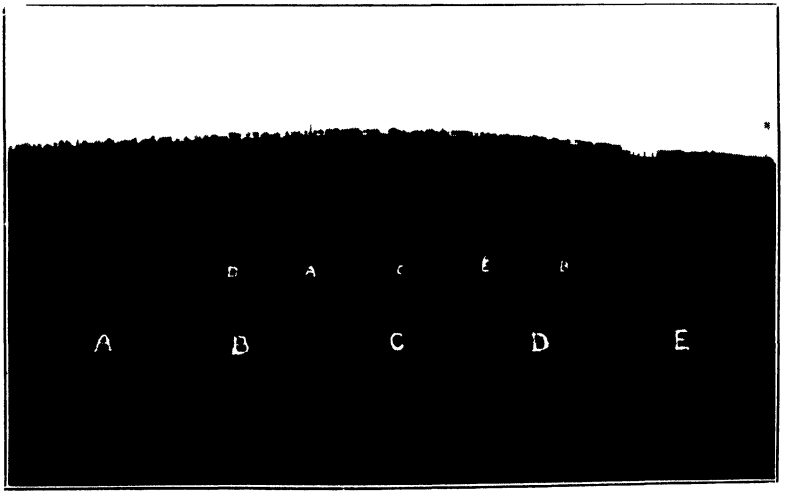

FIG. 2.

Yield trial plots (Gorse Field), 1929-30, photographed April 15, 1930, showing relative resistance to winter-killing,
A—25/1/2/179, B—Grey Winter, C—3/1/3/54 (S81), D—6/3/3/54, E—3/3/3/58 (S82).
The plots lie immediately above their respective symbols.

In Trial 5, lodging was only serious in two of the five replications, and its effects were therefore less apparent than in Trial 6. No lodging of importance was present in any lots in Trials 3, 4 and 7.

Taking the average grain yields in all five trials, we find that the selections 3/1/3/54, 3/3/3/58, 1/2/3/54 and 6/3/3/54 respectively exceed Grey Winter in yield by amounts equal to more than twice the standard error of a difference (Table III). Such yield differences are usually judged as significant.[9] Relative to Grey Winter the general average superiority of the selections is approximately 21 per cent., while the value of z for these comparisons lies between the 5 per cent. and 1 per cent. points, and, therefore, may be regarded as significant.

TABLE III.

Summary of the average grain yields in the five trials (Trials 3—7 inclusive) conducted in the season 1929-30.

	Grey Winter "check."	3/1/3/54 (*S*.81)	3/3/3/58 (*S*.82)	1/2/3/54
Grain, cwt. per acre	20.1	24.1	24.0	24.4
Grain, as percentage of the general mean ...	86.1	103.2	102.9	104.6

	6/3/3/54	25/1/2/179	*Mean.*	*Standard error.*
Grain, cwt. per acre	24.8	22.4	23.3	1.09
Grain, as percentage of the general mean ...	106.6	96.4	100.0	4.69

Standard error of a difference ($\sqrt{2} \times 1.09$) = 1.54 or 6.63 per cent. Value of z for treatments lies between 5 per cent. and 1 per cent. points.

An examination of the straw yields, which are given in Table IV (Trials 3 to 7) shows that the superior grain yields of the selections were obtained without any corresponding increase in the amount of straw produced; the selections being, in general, about equal to or perhaps slightly less than Grey Winter in yields of straw per acre.

[9] Fisher, R.A., and Wishart, J. The arrangement of field experiments and the statistical reduction of the results. Imperial Bureau of Soil Science, Technical Communication No. 10, May, 1930.

TABLE IV.

Summary of average straw yields in eight trials conducted at Frongoch and in the counties during the two seasons 1929-31.

Year of Trial; Trial Reference.	Name or Reference Number of Variety.								
	Grey Winter "Check."	3/1/3/54 (*S.* 81)	3/3/3/58 (*S.* 82)	1/2/3/54	6/3/3/54	25/1/2/179	*Plentiful.*	*Marvellous.*	*Unique.*
1929-30. Trial 3 Cwt. per acre	43.7	39.5	43.1	43.8	40.2	40.8	34.4	29.8	—
Relative weight check=100.	**100.0**	**90.5**	**98.6**	**100.3**	**92.1**	**93.4**	**78.6**	**68.3**	—
1929-30. Trial 4 Cwt. per acre	41.6	42.6	31.9	41.8	42.6	41.2	—	—	—
Relative weight check=100.	**100.0**	**102.4**	**76.7**	**100.4**	**102.5**	**98.7**	—	—	—
1929-30. Trial 5 Cwt. per acre	42.7	43.0	42.6	42.8	42.5	44.0	—	—	—
Relative weight check=100.	**100.0**	**100.7**	**99.7**	**100.3**	**99.5**	**103.1**	—	—	—
1929-30. Trial 6 Cwt. per acre	50.8	53.4	53.4	56.2	54.1	54.1	—	—	—
Relative weight check=100.	**100.0**	**105.1**	**105.1**	**110.6**	**106.6**	**106.6**	—	—	—
1929-30. Trial 7 Cwt. per acre	28.4	29.0	30.2	28.1	28.5	27.6	—	—	—
Relative weight check=100.	**100.0**	**102.2**	**106.2**	**99.0**	**105.5**	**97.1**	—	—	—
1929-30. General Average of Trials 3-7. Cwt. per acre.	41.4	41.5	40.2	42.5	41.6	41.5	—	—	—
Relative weight check=100.	**100.0**	**100.2**	**97.3**	**102.1**	**101.2**	**99.8**	—	—	—
1930-31. Trial 9 Cwt. per acre	44.4	38.9	40.2	42.2	—	—	—	—	47.1
Relative weight check=100.	**100.0**	**87.7**	**90.6**	**95.0**	—	—	—	—	**106.3**
1930-31. Trial 10 Cwt. per acre	18.5	19.6	16.4	20.3	—	—	—	—	—
Relative weight check=100.	**100.0**	**106.2**	**88.6**	**110.0**	—	—	—	—	—
1930-31. Trial 11 Cwt. per acre	29.2	29.3	35.0	29.5	—	—	—	—	—
Relative weight check=100.	**100.0**	**100.5**	**120.0**	**101.1**	—	—	—	—	—
1930-31. General average of Trials 9-11. Cwt. per acre.	30.7	29.3	30.5	30.7	—	—	—	—	—
Relative weight check=100.	**100.0**	**98.1**	**99.4**	**102.0**	—	—	—	—	—
1929-31. Average of all Trials. Cwt. per acre.	37.4	36.9	36.6	38.1	41.6	41.5	—	—	—
Relative weight check=100.	**100.0**	**99.4**	**96.9**	**102.1**	**101.2**	**97.8**	—	—	—

All figures are averages of 5 or 6 times replicated plots.

Acting upon the results of the 1929-30 trials, and having in mind their general appearance and behaviour in preceding seasons, it was decided to proceed with further multiplication of seed stocks of the two selections 3/1/3/54 and 3/3/3/58; and

in the 1930-1 season about 18 acres of the former and 7 acres of the latter were sown with this end in view.

The 1930-31 Trials.

In the fourth and last season, 1930-1, three more trials were laid down (Trials 9, 10 and 11) all at Frongoch. In these comparisons 6/8/8/54 has been omitted owing to its close similarity to 8/1/8/54, and 25/1/2/179 on account of its slightly inferior winter-hardiness compared with 8/8/8/58. In Trial 9, however, Garton's pedigree white winter oat " Unique " was included as a new member.

Trial 11 was advisedly sown late (November 12) in order to accentuate the influences of any possible differential losses occurring through winter-killing.

The average yields of grain harvested in the trials in this season are given in Table II and of straw in Table IV. As in the preceding year no unusually severe winter conditions were encountered; thinning-out occurred in some of the less hardy strains in subsidiary trials and in small beds of Marvellous, but none took place in the members of Trials 9 and 10, which, as in the subsidiary trials, were sown at the normal time. Weather conditions in the spring, however, were for a time distinctly unfavourable to growth.

In Trial 9 the three selections 8/1/8/54, 8/8/8/58 and 1/2/8/54, while falling slightly below in straw yields, were distinctly above Grey Winter in yield of grain. Owing to the season being unfavourable to slightly late maturing autumn-sown varieties, grain-filling in the 8/8/8/58 selection was below normal, and its yield suffered relative to the other selections (Table II). Its percentage husk in consequence was relatively higher in this trial than in Trial 6 (Table VI). The new variety " Unique " had the initial advantage of being new seed, and although growing more rapidly than the other members of the trial throughout the earlier part of the season, was surpassed by a fair margin in yield of grain by the selections 8/1/8/54 and 1/2/8/54. It gave the highest yield of straw and on the score of resistance to lodging it came next to the selections, and was slightly superior to the check variety Grey Winter. Further tests are, however, necessary before the relative value of this new variety can be fully assessed.

In Trial 10, yields generally were low (Table II). This was due to poverty of the soil rather than to any winter-killing, for all plots in this test over-wintered very well in spite of being situated at an altitude of more than 400 feet above sea level and

exposed to strong south-westerly gales blowing in direct from the sea. All selections showed yields greater than those of Grey Winter, the results being in general agreement with those of Trial 9.

Plots in the late sown trial (Trial 11) looked poor and remained backward throughout the winter and early spring months; brairding and establishment in all plots were distinctly thinner than in Trials 9 and 10, and ripening was delayed. Yields were decidedly lower than in Trial 9 situated nearby, but the selections have, nevertheless, maintained their higher average yields compared with Grey Winter (Table II). In this trial 3/3/3/58 was easily best. Its superiority here was probably due to the inherent capacity of this selection to tiller freely and recover well in late spring and early summer, especially when the spring establishment is somewhat thin and poor, and fertility conditions are reasonably good. Its relative straw yield was much higher than in Trials 9 and 10, in which satisfactory spring plot establishments existed, and also higher than its average relative amount in the preceding season (Table IV).

Taking the three trials together the average grain yields of 3/1/3/54, 3/3/3/58 and 1/2/3/54 relative to Grey Winter at 100 are 120.7, 112.6 and 122.2 respectively (Table II). The figures for the first and last named selections agree very closely with their averages in the five trials of the preceding season, namely, 119.9 and 121.4 respectively. Selection 3/3/3/58, however, compares rather less favourably owing, as already indicated, to differential seasonal effects in respect of grain formation especially in Trial 9.

Straw yields in general need little comment. These, as will be seen from Table IV, were on the average approximately equal to Grey Winter, and in this respect agreed closely with their relative positions in the preceding season Comparing grain and straw yields it will be seen that the grain-to-straw ratio, as in the preceding season, is higher in the selections than in Grey Winter.

General Reaction to Climatic Conditions.[10]

In autumn-sown oats the general climatic conditions prevailing in the months October to March, and sometimes April, are extremely important in their influence upon crop yields, owing largely to their effect upon winter-killing. The four seasons in which the above trials were conducted may be broadly

[10] The information bearing on weather conditions has been kindly supplied by Mr. Ll. Iorwerth Jones from the Station's Meteorological Records.

divided into two severely cold winters (1927-8 and 1928-9) and two relatively mild winters (1929-30 and 1930-1). In the 1927-8 winter, however, relatively dry weather prevailed during the period October to December, with hard frosts and severely cold conditions during part of November and the whole of December. Damp and relatively mild conditions followed with cold spells in February and March, and very dry, cold weather in April.

In 1928-9 the last three months of the year were very wet, rain falling on 75 days out of 92;[11] but temperatures in general were not low. The first four months of the new year, however, were the exact opposite, being very dry, and unusually low temperatures were experienced. Snow and frost were of frequent and prolonged occurrence, and thermometer readings of 27 degrees of frost were recorded at Frongoch.

The October-December period in the milder winter 1929-30 was marked by exceptionally wet conditions; rain fell on 80 days and the unusual total of 24.98 inches was recorded. Apart from a dry, cold spell in February the early spring months were of an average character.

The 1930-1 season was again wet and mild in the first period, but the months January to April were generally wet and cold, although no unusually low temperatures were noted.

In relation to these varied climatic conditions the best yields were obtained in the 1929-30 season, when the very wet autumn and early winter conditions were followed by a fairly propitious spring. The poorest yields occurred in the 1930-1 season, where a combination of wet and cold conditions over a prolonged period in the spring severely checked the normal progress of growth and depressed both grain and straw yields. A direct comparison between the 1929-30 and 1930-1 seasons must, however, be discounted to some extent, for all trials in the 1929-30 season received light top-dressings of nitro-chalk, whereas those in 1930-1 had none. Also the not unimportant effects of differences in the summer growing period must be borne in mind. Although actual yields differed, the yields of 8/1/8/54 and 1/2/3/54 relative to Grey Winter remained unchanged in these two seasons and their superior grain-to-straw ratio was maintained.

In the two years when the winters were severely cold, actual yields of grain compare quite favourably with those in the milder seasons. This is to some extent due to the degree of recovery which is possible when a crop is not unduly thinned-out and

[11] Calculated on a basis of the number of days when the rainfall equalled or exceeded 0.01 inches.

spring conditions are such as to encourage tillering and so the making good of losses due to winter-injury. Relative yields, however, showed a wider contrast, especially in the 1928-9 season, and place Grey Winter in a more favourable position relative to the selections. In the two milder winters, however, relative yields were distinctly in favour of the selections.

TABLE V.

A comparison of the average grain yields in cwt. per acre over the four seasons 1927-31.

Variety.	1927-8. (*one trial*).	1928-9. (*one trial*).	1929-30. (*five trials*).	1930-1. (*three trials*).	*Average of four seasons.*
Grey Winter "check"	19.6	21.8	20.0	18.6	18.8
8/1/8/54 (S.81)	18.6	18.0	24.0	16.8	19.2
8/8/8/58 (S.82)	16.1	17.4	23.9	15.2	18.2
1/2/8/54	22.5	12.8	24.3	16.5	19.0

Standard error of the mean = 1.96. Standard error of a difference ($\sqrt{2} \times 1.96$) = 2.75. Value of z for treatments approaches significance on the 1 per cent. test.

The average yields over the four seasons are brought together in Table V. On the basis of actual yields 8/1/8/54 exceeded Grey Winter by the narrow margin of 0.4 cwt. per acre; 1/2/8/54 by the smaller margin of 0.2 cwt., while 8/8/8/58 has fallen short by 0.6 cwt. per acre. These comparisons examined by the z test closely approach significance on a 1 per cent. basis, the odds being that a similar result would occur by chance about once only in a hundred such trials. In relation to the standard error test it is indicated that on the average of the seasons, good and bad included, individual selections appear to be about equal to Grey Winter in mean yields of grain.

In size and quality of grain (Table VI) the selections as a whole differ from Grey Winter in having slightly smaller grain and a very slightly higher proportion of husk. In this latter respect, however, they compare favourably with the spring variety Victory.

General Remarks.

Of the three selections continued up to final stage of the trials, 8/1/8/54 appeared throughout the whole period of breeding and testing operations to be the most winter-hardy strain. It has fairly consistently given good yields of grain and can,

FIG. 3.

Field trial plots (Gorse Field), 1928-9, photographed August, 1929, showing relative resistance to lodging.
Foreground: left, 3/3/3/58 (S82); right, Grey Winter.

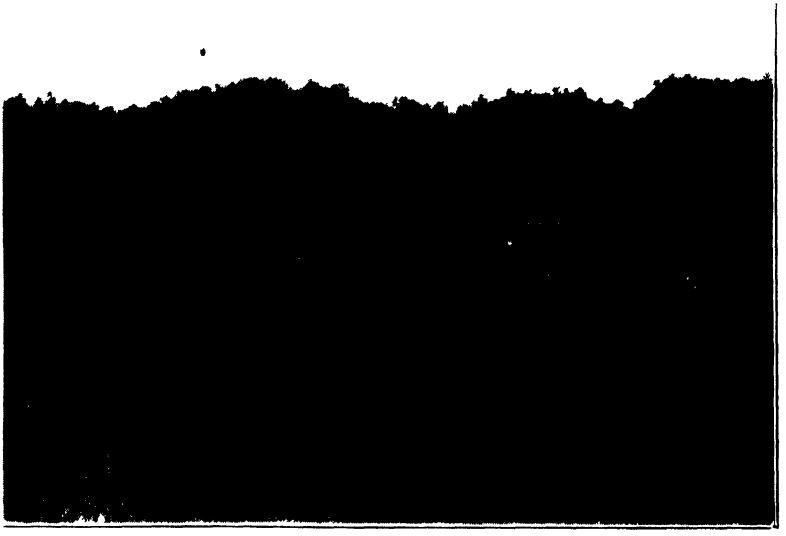

FIG 4.

Field crop, photographed August, 1931, showing relative resistance to lodging.
Left-hand corner, Black Winter; right, 3/1/3/54 (S81).

provided a reasonable plant establishment is present in the spring, be generally relied upon to outyield the commercial variety Grey Winter. Compared with the latter its straw is of good quality, slightly shorter and stiffer, and, unlike that of the grey variety,

TABLE VI.

Comparisons of percentage husk and grain weight.

	Grey Winter "check."	3/1/3/54 (*S*.81)	3/3/3/58 (*S*.82)	1/2/3/54	*Victory (spring-sown).*
PERCENTAGE HUSK.					
"First" grains (seed *ex* trial 6)	23.02	26.74	25.33	28.00	29.1
Ungraded grain (seed *ex* trial 9)	19.80	22.70	29.10	25.40	27.8
Average ...	**21.42**	**24.72**	**27.21**	**26.70**	**28.4**
GRAIN WEIGHT IN GM.					
Per 1000 "first" grains ...	42.0	38.9	40.8	40.5	43.3
Per 1000 ungraded grains ...	29.4	30.4	26.5	31.1	36.0
Average ...	**35.7**	**34.6**	**33.6**	**35.8**	**39.6**

does not, when approaching maturity, lodge with every shower of rain. In the 1931 season, crops of 65 bushels per acre were harvested in a good upright condition (Fig. 4). This selection ripens at about the same time as Grey Winter, but comes into ear a week or more later than that variety; this gives it a slight disadvantage in appearance during the early pre-heading and heading stages of growth when seen alongside the grey variety, due mainly to differences in relative heights and rates of growth at this period. These differences, however, disappear as full heading is reached and thenceforward its dense spreading head and less resilient straw give it a more attractive appearance than Grey Winter.

The selection 3/3/3/58, while rather less hardy than 3/1/3/54 in its resistance to winter conditions, possesses an inherent capacity to respond to good treatment or good weather conditions in the spring. It tillers freely and is very responsive to intensive manurial treatment such as top dressings of nitrogen in the spring. Its straw is longer than that of 3/1/3/54, and without being coarse is remarkably stiff, clean and resistant to lodging. Apart from one instance, in the 1930-1 season, no serious lodging has occurred in the trials in this particular variety. On account of its high resistance to lodging and its responsiveness to good soil conditions 3/3/3/58 should be sown

in preference to 3/1/3/54 where the expectations of yield are upwards of 60 to 65 bushels per acre. On land of 65 bushels expectation or less, 3/1/3/54 is believed to be preferable on account of its relatively higher grain-yielding capacity under such conditions. Selection 3/3/3/58 ripens from five to seven days later than Grey Winter and comes into ear almost a fortnight later than this variety. What has been said above, of the appearance of the 3/1/3/54 strain relative to Grey Winter in respect of relative appearance at this stage of growth applies equally to this selection. Like 3/1/3/54, 3/3/3/58 has a fairly dense spreading head with numerous spikelets and possesses a good grain-yielding capacity under average seasonal conditions.

Selection 1/2/3/54 has slightly larger grain than 3/1/3/54, and although equalling it in grain-producing capacity and surpassing it slightly in resistance to lodging, does not appear quite to equal it in general winter-hardiness. Its leaf-tips are inclined to show slight winter-burn in most seasons, though its yield only fell off severely in the 1928-9 season. This strain has, therefore, been withheld for further observation.

In the autumn of 1931 a preliminary and experimental distribution was made of seed stocks of 3/1/3/54 and 3/3/3/58 under the designations " Aberystwyth White Winter Oats S.81 " and " Aberystwyth White Winter Oats S.82 " respectively.[12] These two new varieties are considered to rank next to Grey Winter in respect of winter-hardiness and to be about equal in hardiness to the variety Black Winter. They are markedly superior to both Black and Grey in their resistance to lodging, and it is with a view to gaining information as to their possible usefulness as alternatives to these older varieties that this experimental distribution has been made. In ratio of weight of grain to weight of straw the two strains are superior to the Grey Winter oat.

The writer is of the opinion, formed by observation on these and other trials, that where conditions of soil or climate or both are very exacting to autumn-sown oats, as is the case in many districts in Wales, sowing at a time most suitable to the district is a very important factor in their successful cultivation.

[12] The seed stocks of these two strains were not, however, entirely free of grey grains which unfortunately and inadvertently found their way into these preliminary stocks during harvesting and growing-on processes. Their amount is negligible, but pure stocks are nevertheless being built up and will shortly be available should the distribution prove successful and a demand arise for new and fresh supplies of pure seed.

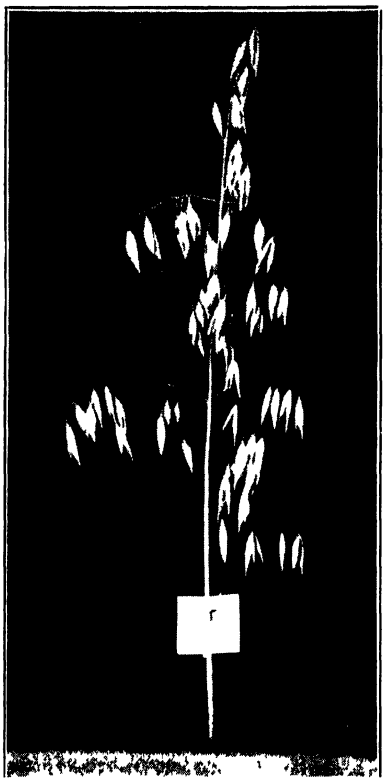

FIG. 5.

Representative head of Variety S81.

FIG. 6.

Representative head of Variety S82.

For most districts in Wales that optimum time falls within the limits of the period mid-September to the end of the first week of October, and in September more often than in October.

Brief descriptions of the New Varieties.

S.81. Young plant semi-prostrate, leaf sheaths and leaf margins hairy. Leaves darker green and slightly broader than those of Grey Winter. Tillering good. Markedly resistant to frost and prolonged periods of wet weather on reasonably well drained soil. Comes into ear about four to five days later than Grey Winter, but ripens at about the same time as that variety. Panicle or ear, open or spreading, fairly large with fairly stiff, straight or slightly ascending branches and stiff, straight or slightly curved rachis. Spikelets numerous and two-grained. Grain white, with very slight yellowish tinge, rather smaller than Grey Winter, very free from awns and of good quality. Straw fairly stout and of good feeding quality, slightly shorter and more resistant to lodging than that of either Grey or Black Winter (Fig. 5).

S.82. Young plant prostrate or semi-prostrate, leaf sheaths and leaf margins hairy. Leaves dark green, slightly narrower than those of S.81 and less erect. Tillering very good. Very slightly more susceptible to winter-killing than S.81, but tillering freely, recovers well and responds readily to good conditions in the spring. Comes into ear about seven to nine days later than Grey Winter, ripening about a week later than that variety. Panicle open or spreading, fairly large; branches not long, drooping slightly, bearing fairly numerous two-grained spikelets. Grain white, smooth, rather less pointed than S.81, somewhat smaller than Grey Winter, free from awns and of good quality. Straw not stout, fairly long, very stiff and markedly resistant to lodging (Fig. 6).

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The Station is deeply indebted and records its thanks to the following persons, who have in one or more seasons willingly provided land for yield trials, observation plots or growing-on of seed stocks, and whose enthusiastic and helpful co-operation in harvesting, threshing and other operations has been of much assistance in the conduct of the work :—Messrs. Simon Davies, Green Grove, Felinfach, Cards.; D. J. Davies, Tynycoed, Nantgaredig, Carms.; F. T. Edwards, Marsh Court, Bridge Sollars, Hereford; J. D. Hopkins, Bronllys Court, Talgarth, Breconshire; R. L. Jones, Penwenallt, Newcastle Emlyn, Cards.; J. L. Morris,

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The writer has much pleasure in acknowledging his indebtedness to Professor R. G. Stapledon, M.A., under whose direction the work has been carried out, to various members of the Station staff, and to Mr. Percy George, M.A., Department of Economics, for their helpful criticism and suggestions in the planning and treatment of the experimental work; also to Miss Rhoda Jones, B.A., for assistance in the preparation of the manuscript.

IN QUEST OF THE BEST SAINFOIN.

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I. The Problem.

Sainfoin is a very valuable forage on account of its high protein and nutritive constituents, and farmers who cultivate it assert that it has valuable tonic properties. We might define the best sainfoin as the one which would continue to give the greatest yield of the best feeding value for the largest number of years, that is, the farmer requires high yield, persistence and quality so as to get the biggest return for his outlay on seed and cultivation. The yield of a crop at any time will depend on the weight of produce from the individual plants, and on the area being covered by the optimum number of plants that will give the maximum yield. We shall, therefore, see that the problem consists in examining yields, and that continued high production depends on the persistence of the plants, their hardiness and resistance to diseases under local conditions of soil and climate. This problem then will be applied to South Wales conditions around Cardiff, and to those soils which are sufficiently well drained and contain enough lime to grow sainfoin satisfactorily.

II. Material and methods.

How is the sainfoin that will meet these requirements to be obtained? Pursuing this problem, one has to make use in the first place of the available material. The sainfoin generally cultivated in this country falls into two agricultural divisions, namely, Common and Giant, the seed of which may be either raised at home or on the Continent. The chief distinction between Giant and Common Sainfoin is that Giant grows quickly and tends to run into flower early in the seeding year. In the harvest year, the first flowering period of the two sorts is approximately identical, but the aftermath recovers more rapidly and flowers earlier in the case of the Giant, and a second cut of hay is generally taken and again the aftermath flowers, whereas the aftermath of the Common tends to remain leafy, with very little tendency to flower later. As a general rule, the Giant forms are short-lived, the yield declining rapidly after the second year, whereas the Common forms may yield good crops for a large number of years. It is in this permanency that Common sainfoin will prove superior to red clover, as the yield of hay is about the same.

The question of nationality of red clover has received much attention, but this has not been the case with sainfoin. In the present paper the relative yield and persistence of lots of Giant and Common sainfoin obtained from different sources will be discussed. The seed of Giant sainfoin is usually French or English grown. The Common sainfoin lots that have been included in our trials at the experimental ground at the Green Farm, near Cardiff, were of French, Italian, Moravian, and English origin. The English lots are often further sub-divided into Eastern Counties, Hampshire, and Cotswold, whilst we may add also a local Glamorgan.

These lots have been tested by growing in drills containing an equal number of seeds in 1926, an equal number of viable seeds in 1927, and spaced plants in 1928, 1929, and 1930. In no case was any cover crop sown on the plots. The method will be described under the detailed account of the experiments.

A test involving persistency should necessarily proceed for a large number of years, and those discussed below are still in progress, but some facts are indicated which it may be desirable to record at present.

III. Account of experimental work and data.

(1) NATIONALITY TESTS STARTED IN 1926.

(*a*) *Experiment with Giant sainfoin.*

In 1926 eleven lots of sainfoin, nine French, and two, Nos. 8 and 9, English, which purported to be Giant, were sown in duplicate three row plots with an equal number of seeds. The dates of first flowering and cutting in 1926 were :—

Aug. 5	...	Lots 6, 7, and 8.
,, 11	...	,, 1, 2, 3, and 11.
,, 19	...	,, 10.
,, 30	...	,, 9.
Sept. 13	...	,, 4 and 5.

and all except the French lots 4 and 5 flowered again and were cut a second time on September 22. The Giant form is generally recognised by the earliness and frequency of flowering in the seeding year, and also by the quick recovery of the aftermath. Therefore, 4 and 5 have to be classed as Common. Three cuts were taken in 1927, except of lots 4 and 5, which again showed their Common character by their high yield for hay and low yield for aftermath cuts. This was also the case to some extent with the English lot 9, which was somewhat late flowering in the seeding year.

In this trial, which lasted only two seasons owing to the Giant lots thinning out at the end, the Common have not shown any superiority of yield over the Giant lots taken as a whole, and when two cuts of hay are desired, the verdict would be in favour of the Giant. The number of English lots was too small to assign any significance to the question of origin.

(*b*) *Experiment with Common sainfoin.*

As our problem is concerned with persistence and hardiness, the rest of this paper will be devoted mainly to consideration of Common lots.

Table I includes particulars, together with some observations on some of the twenty-one lots regarded as Common received from seed merchants in 1926, and sown in triplicate plots, with one lot (No. 7) repeated four times at different places as a check plot. Equal numbers of seeds equally spaced were sown in all the plots.

The general habit of the lots was noted in July, 1927, and the amount of plants of " g " type, which send up central stem and resemble Giant in the quick recovery of the aftermath after cutting for hay and early second flowering and possibly third

flowering in the same year; and of "c" type, in which the aftermath after the first cut remains leafy, for some typical lots is shown in Table I. In all the lots described in the Table the germination and brairding was good and about equal.

TABLE I.

Lots. C.	*Origin.*	*State of flowering on* 18.8.26.	*Type of aftermath.* 20.7.27.	*Whether flowering on* 12.8.29.	*Whether flowering on* 23.8.30.	*Nature of stand on* 20.5.31.
3	English Herts.	Trace.	Very few G.	Yes.	Trace.	Thin.
6	English Hants.	None.	C	None.	None.	Thick.
7	English Hants.	None.	C	None.	None.	Thick.
8	English Hants.	None.	definitely C.	None.	Trace.	Thick.
9	English Eastern Counties.	Few.	intermediate C and G	Yes.	Yes.	Thin.
10	English Eastern Counties.	None.	Few G, some intermediate	Yes.	Yes.	Thin.
12	English True Cotswold.	None.	C	None.	Trace.	Thick.
13	English True Cotswold.	None.	C. All late.	None.	Trace.	Thick.
14	French Champagne.	Some.	G	Dead.	Dead.	Dead.
16	Italian.	Many.	Two-thirds G. One-third intermediate	Dead.	Dead.	Dead.
17	Moravian.	None.	One-half C. One-half intermediate	Dead.	Dead.	Dead.

Particulars of the date of cutting of these lots, which also coincide with the order of flowering of the plots, are given in Table II.

TABLE II.

Dates of cutting from 1926—1931 of some common sainfoin lots sown in 1926.

Lot and origin.	1926.	1927. *Hay.*	1927. *Aftermath.*	1927. *Aftermath.*	1928. *Hay.*	1928. *Aftermath.*	1929. *Hay.*	1929. *Aftermath.*
3 English Herts.	21.9.26.	10.6.27.	11.8.27.	No 3rd cut.	11.6.28.	3.8.28.	17.6.29.	20.8.29.
6 Hants.	21.9.26.	10.6.27.	11.8.27.	No 3rd cut.	11.6.28.	12.9.28.	17.6.29.	26.8.29.
7a Hants.	21.9.26.	10.6.27.	26.8.27.	No 3rd cut.	11.6.28.	12.9.28.	17.6.29.	26.8.29.
8 Hants.	21.9.26.	10.6.27.	11.8.27.	No 3rd cut.	11.6.28.	12.9.28.	17.6.29.	26.8.29.
9 Eastern Counties	13.9.26.	13.6.27.	11.8.27.	No 3rd cut.	11.6.28.	3.8.28.	18.6.29.	28.8.29.
10 Eastern Counties	13.9.26.	13.6.27.	11.8.27.	No 3rd cut.	11.6.28.	3.8.28.	18.6.29.	28.8.29.
12 Cotswold	21.9.26.	11.6.27.	11.8.27.	No 3rd cut.	11.6.28.	12.9.28.	17.6.29.	26.8.29.
13 Cotswold	21.9.26.	11.6.27.	27.8.27.	No 3rd cut.	11.6.28.	12.9.28.	17.6.29.	26.8.29.
14 French	13.9.26.	13.6.27.	4.8.27.	5.10.27.	No	further	cuts.	
16 Italian	21.9.26.	13.6.27.	4.8.27.	5.10.27.	No	further	cuts.	
17 Moravian	22.9.26.	13.6.27.	26.8.27.	No 3rd cut.	No	further	cuts.	

Note.—In 1930 hay was cut on June 26 to 27, and aftermath on September 4 to 5.
In 1931 hay was cut on June 25, and aftermath on September 21 to 22.

The germination was unknown and therefore yield results were expressed as percentages of the first cut of the seeding year (1926), and are presented in the case of the above plots in Table III.

It was noticed that plants were dying in lots 17, 18, and 19, Moravian, on October 8, and in lots 14, 15, French, and 16,

Italian, in November of the first harvest year, and to a slight extent in lot 21.

TABLE III.

Showing relative hay and aftermath yields of some lots sown in 1926, expressed as percentage of the autumn cut of the seeding year 1926 for that lot, and total of all cuts expressed as percentages, and actual.

Lot.	*Origin.*	1926. *Actual.*	1926-7.	1927. *Hay.*	1927. *First Aftermath.*	1927. *Second Aftermath.*	1928. *Hay.*	1928. *Aftermath.*	1929. *Hay.*	1929. *Aftermath.*	1930. *Hay.*	1930. *Aftermath.*	1931. *Hay.*	1931. *Aftermath.*	*Total as percentages of 1926.*	*Total oz. of green dry forage.*
3	Herts.	714	100	216	99	—	76	44	186	98	113	100	58	63	1160	8286
6	Hampshire.	593	100	262	124	—	137	147	229	131	194	139	143	98	1700	10120
7a	Hampshire.	508	100	346	169	—	178	158	290	147	245	160	182	117	2100	10655
8	Hampshire.	543	100	303	147	—	115	176	316	145	218	159	187	119	1925	10448
9	Eastern Counties.	731	100	202	100	—	96	43	193	74	106	77	44	36	1075	7884
10	Eastern Counties.	780	100	218	113	—	82	48	187	91	117	106	70	65	1204	9391
12	Cotswold.	546	100	260	117	—	131	141	256	129	252	127	200	106	1790	9783
13	Cotswold.	515	100	338	163	—	111	136	231	128	199	118	162	96	1485	9195
14	French.	707	100	198	100	38	—	—	—	—	—	—	—	—	437	3076
16	Italian.	574	100	204	89	65	—	—	—	—	—	—	—	—	470	2639
17	Moravian.	531	100	289	165	—	—	—	—	—	—	—	—	—	510	2682

Thus the French, Italian, and Moravian lots gave no cut for hay in 1928, and lot 21 of unknown origin and description gave only a very small yield that season.

Reference to the full data shows that the yields of Hampshire (lots 5, 6, 7, 8, 22) and Cotswold (lots 12 and 18) expressed as percentages of the cut in 1926 take the lead. Probably lot 4 is Hampshire. The Eastern Counties (9 and 10), Essex (11), and Hertfordshire (3) lots fall into the next lower distinct group, whilst the undescribed lot (21) and the English (1 and 2) might be placed in the same group and possibly are of Eastern Counties or of mixed origin. The French and Italian, whilst different in habit, come into the same yield group as Moravian. Whether the difference between the high and low yielding is due to admixture of more or less " Giant " blood in the latter, or is due to these seeds coming from a drier and warmer climate is not easy to determine. This experiment indicates that the further we travel in search of seed the less permanent and lower yielding are the crops.

(2) EXPERIMENTS WITH DIFFERENT LOTS OF SAINFOIN IN 1927.

The main purpose of this experiment was to examine further the difference between lots of Common sainfoin available from the chief seed firms of this country. A few lots of Giant were included for comparison. Seed of Common cannot be distinguished from that of Giant, and therefore the grower's word as to kind has to be accepted, and the merchants sell without a guarantee. The main character could be told by field inspection of the aftermath or by growing on in test drills. It has been seen, however, that in some lots there may be more or less of what appears to be an admixture of types and it may be that persistence is not strictly linked up with flowering habit in every case.

(*a*) *Drill plots.*

Twenty lots of known origin and germination were obtained and were sown on the basis of equal number (480) of viable seeds according to the seller's quotation in 20 ft. drills in three series of four drills per lot. Series I were sown on August 9-10, 1927, the soil working well and in nice condition, and the plants appeared in six days. Series II, lots 1 to 8, were sown on June 14, lots 9-21 on June 25 to 27. The plants appeared through the ground in seven to eight days. Some damage was done to this series through bird attack. Series III, lots 1 to 8, were sown on July 29, and lots 9 to 21 on July 25, and all came through in five or six days.

Vendor's particulars of the origin, the number of seeds sown per row of 20 feet based on seller's statement, and the plant counts for three rows of 20 feet each about four to six weeks after sowing in the plots are shown for some of the lots in Table IV.

TABLE IV.

Showing the particulars, counts, and aggregate yields of hay and aftermath in 1928, 1929, 1930, and 1931, of lots sown in 1927 and the yields of 1931 and totals for four years expressed as percentages of yields for 1928.

Lot.	Origin.	Seeds sown per row on a basis of 480 viable.	Counts of plants in 3 rows of 20 ft. in 1927.	Hay and Aftermath 1928.	Hay and Aftermath 1929.	Hay and Aftermath 1930.	Hay and Aftermath 1931.	1931 expressed as % of 1928.	Total for 4 years.	4 years total expressed as % of 1928.
				ozs.	ozs.	ozs.	ozs.			
2	Essex.	522	1040	841	1096	961	767	91	3665	435
3	France.	522	1372	621†	729†	365†	350	56	2065	333
5	Hampshire.	533	982	572	863	948	862	150	3140	548
6	Oxford.	545	1015	617	947	981	1002	162	3497	566
8	Giant English.†	500	1092	490†	660†	146†	90	19	1386	283
9	Cotswold.	539	539	489	870	850	853	174	3062	627
10	Hants.	593	524	641	861	985	841	131	3278	590
14	Wilts.	558	897	664	753	958	999	150	3369	508
15	Hants.	593	948	656	955	1186	1092	160	3889	584
16	N. Suffolk.†	686	1001	581†	777††	569	843	158	2720	522
20	Cambs. G.*†	1066*†	954	757†	886†	525	690	91	2858	377
21	Moravian.*	706*	335	342	642	280	132	38	1396	415

* An error occurred and the seed of these were sown at wrong rates, No. 20 being too high and No. 21 too low.

† The cuts of 1927 are included with those of 1928, and the third cuts of 1928 with those of 1929, and of 1929 with those of 1930 in lots 8, 16 and 20.

The 1927 lots could be classed roughly into :—

Giant English	Lots 8 and 20.
Common Foreign, French	,, 3.
Common Foreign, Moravian	,, 21.
Common English, Eastern Counties ...	,, 1, 2, 4, 11, 14, 16, 17, 18, and 19.
Common English	,, 7.
Common English, Hampshire	,, 5, 10, and 15.
Common English, Berkshire and Wiltshire	,, 12 and 13.
Common English, Oxford and Cotswold ...	,, 6 and 9.

The plot and greenhouse germinations varied from the official figures which were taken as a guide for sowing the plots. This discrepancy might be accounted for by the later date and different environment of the former tests. There was also variation in plot germination between the series. Thus there is considerable difficulty in comparing lots on the basis of actual yield per drill, and on the other hand, calculations of relation of the yield to number of plants are impossible owing to the difficulty of counting plants which are not spaced. Possibly the yield per drill would be comparable if the number of plants were approximately equal, as to a certain extent the size of the plant increases with the amount of space given to it. The total yield of some typical lots for four years and the yield of hay plus aftermath in the last year, 1931, expressed as percentage of the yield of its hay plus aftermath in the first harvest year are shown in Table IV and follow the above classification of the origin.

The amount of " g " type in lots 7, 11, and 16 in the late summer of 1929 was negligible, and no third cut was taken; so with lot 8, Series II in 1929, and lot 11, Series I, in 1928. The taking of a very late cut in the season appears to reduce the hay yield of the following year, as shown by the hay yields in 1928, 1929, and 1930, apart from the tendency of these lots to be short-lived. How far the cutting is excessive and how these lots would persist under different management are problems that have not been investigated.

The Continental lots, particularly the French, partake of Giant character, which we may call now the " g " type, which tends to die out in the course of time, leaving the Common, or " c ", type predominating in the later years. The Moravian, especially when considered in conjunction with the results of other experiments, is seen to consist of a large number of short-lived plants, though this particular trial cannot be considered quite fair, on account of the number of plants that were initially established. Those lots from the Eastern Counties of England generally have shown a tendency towards the " g " type, as regards falling off in yield, except perhaps lot 16, which had a very high position in 1931, whereas its place in 1930 was quite low, but its " g " character was unmistakeable.

The Cotswold lot was obtained from a genuine old stock, and in spite of low germination has gained strength and shown to great advantage on the basis adopted for comparison. It is possible that the Oxford and Wiltshire lots could be characterised as Cotswold, although then we have not sufficient grounds for saying that the Cotswold excels the Hampshire and other

lots from the south of the Thames, and in view of later trials this seems to be fair.

(*b*) *Plots of spaced plants.*

Further, a preliminary attempt at a population analysis of some of these lots was started later by transplanting plants raised in other beds of lots 3, 5, 6, 8, 10, 13, and 20, and setting out at distances of about twelve inches apart as spaced plants which were numbered and could be traced. The persistence of the plants contained in these lots is roughly indicated in Table V, and appears to be correlated with a prostrate or semi-prostrate habit of the aftermath and early spring growth. The total number of plants at hay time in 1928 and the percentage of these surviving at hay time in 1929 and 1930 are shown. The results for 1931 are still more striking.

TABLE V.

Showing the percentage number surviving at different dates of 1927 lots as spaced single plants.

Lot.	*Origin.*	*No. of plants surviving at hay time,* 1928.	*Percentage of surviving plants,* 24.5.29.	*Percentage of surviving plants,* 20.6.30.
3	French Common	121	74	24
5	Hants Common	234	50	42
6	Oxford Common	132	60	53
8	English Giant	96	59	6
10	Hants Common	120	53	35
13	Wilts Common	107	78	68
20	Cambs. Giant	125	80	34

Exact correlation between percentage survival and yield is not to be expected, especially when the yield of drills and the number of spaced plants in different plots are involved. Casualties are probably heavier in the case of spaced plants but the two results seem to confirm each other within reasonable limits. These lots were taken at random for this study, but it will be seen that the Oxford and Wilts. again fall into one class, Hampshire into another, and that the Giant and French are variable. The Cambridge Giant appears to be a really more persistent strain than the usual lots of Giant, but two instances are known of sainfoins of certainly Giant type giving two reasonable hay crops annually for some five years in succession in the Vale of Glamorgan, so that this may be another of the same kind.

(8) STUDIES OF VARIETIES SOWN IN 1928.

In 1928 four lots of Giant and five lots of Common were sown in field demonstration plots, and samples were kept for population studies at the experimental ground. Only general observations were possible on the farms where no counts or weights were taken, but it may be mentioned that in the first year all the lots seemed to take well when sown at a rate approximately corresponding to the quoted germination, allowing an average of ½ cwt. per acre for the milled and 1 cwt. per acre for the unmilled.

After the first season the Giant and Moravian lots thinned out, though the two English Giants appeared to be thicker than the Moravian. There was not much difference between the lots of Hampshire and the Cotswold for some years, but in 1931 the Cotswold seemed to be holding its own best against weed competition at one of the Glamorgan centres.

At the experimental ground groups of about five seeds were sown eighteen inches apart with eighteen inches between the rows, the lots being replicated in different parts. After the first pinnate leaf had developed the groups were thinned, leaving full plots of spaced single plants, so that there was hardly any need to transplant to fill up gaps.

In the case of Giant sainfoin the number of plants surviving at different times was noticed to be higher for the English than for the French, but as the number of lots is small, much significance should not be attached to this fact. The plots had thinned out so much by May, 1930, that they were discontinued.

Table VI shows the number of plants left in each plot and the number of plants surviving at different dates in respect of the five lots of Common. The proportion of plants in flower late in the seeding year and in the aftermath of the following three years are also shown.

Little comment is necessary on this experiment except to point out again the high mortality of the Moravian lots, which is almost as serious as that of the Giant mentioned above, and that in this case, so far, the Cotswold lot is not standing as well as the Hampshire lots. Casualties occurred at a higher rate in the winter of 1928-29, in June of 1929, in the winter of 1929-30, and in the case of Moravian in the winter of 1930-31, and still more after the hay cut of 1931. The survival of the lots at the end of the summer of 1931 appears to bear some relation to the tendency to flower in the autumn of the seeding year. The proportion of plants flowering in the aftermath

seems to have diminished rapidly in 1931, and it will be interesting to see if this decrease will ultimately be correlated with the persistence of the remaining plants.

TABLE VI.

Lots and Origin.	No. of plants, Sept. 17, 1928.	Percentages of plants surviving.								Percentages of the aftermath plants flowering.			
		May 17, 1929.	*June* 18, 1929.	*July* 30 to *Aug.* 9, 29.	*June* 12-13, 1930.	*Aug.* 2-6, 1930.	*May* 20, 1931.	*Aug.* 25, 1931.	*Oct.* 10, 1928.	*July* 29, 1929.	*Aug.* 12, 1930.	*Aug.* 25, 1931.
E. Moravian.	254	91	84	84	50	48	39	22	21.8	87	69	53
F. Hampshire.	290	97	95	95	86	86	85	81	.6	85	69	45
G. Hampshire.	301	94	94	93	86	86	83	79	.3	75	65	38
H. Hampshire.	296	90	87	87	76	75	74	69	.3	82	85	57
J. Cotswold.	387	91	89	89	73	73	70	62	8.2	82	70	40

(4) EXPERIMENTS STARTED IN 1929 AND 1930 WITH LOTS OBTAINED IN 1929.

Plots were arranged in a way similar to that adopted in the 1928 experiment, in 1929, with six lots of seed, viz., a certain strain from the Vale of Glamorgan, two lots of Cotswold, and one

lot each of Hampshire and Eastern Counties Common, and one Giant. In 1930, one lot of Giant which had been giving two good hay crops annually on a local farm for five years and another lot of Common from Suffolk were added. This test has not proceeded long enough to draw definite conclusions, but some particulars are given in Table VII because they appear to confirm previous results and indicate the nature of the lots tested.

TABLE VII.

	1929.		*Percentage surviving.*				
	No. of original plants.	*Percentage flowering.*	*May 5, 1930.*	*June 11, 1930.*	*Aug. 15, 1930.*	*June 15, 1931.*	*Aug. 25, 1931.*
1. Common Glamorgan	206	2.4	57	51	51	51	49
2. Common Cotswold	205	3.4	52	46	46	46	39
3. Common Cotswold	207	2	57	49	49	48	42
4. Common Hampshire	208	14.7	68	58	58	56	46
5. Common Eastern Counties	205	69	43	32	30	22	9
6. Giant Bedfordshire	81	92	35	19	19	11	8

These figures again seem to show that Eastern Counties sainfoin is not suited to Glamorgan conditions, and in the first season is less persistent and useful than Giant sainfoin. The Hampshire leads especially in the early years, but it may be that after many years the more local strain would show its merits.

(5) EXPERIMENTS WITH LOCALLY COLLECTED SEEDS AND PLANTS.

Lots of local seed were sown at different times. In 1926 lots A and B were collected from plants which established themselves on railway banks, and lot D in a field sown with a local strain of Vale of Glamorgan or " old sort ". The plants on the railway bank probably originated from commercial seed sown in a field through which the cutting was made about forty years previously. The " old sort " had been in cultivation in the Vale and in many cases on the same farm for upwards of half a century and was recognised locally as the most reliable. It is feared that this stock is now extinct except for the plants on the plot. The number of plants of these lots planted and those surviving

at different dates are shown in Table VIII together with the average weights.

TABLE VIII.

Showing the number of plants surviving at different dates, and their average green weight. Seed collected locally in 1925 and set out as spaced single plants in 1926.

Lot.	1927.		1928.		1929.		1930.	
	8.7.27	6.9.27	25.6.28	24.9.28	19.6.29	29.8.29	23-5.6.30	27.8.30
A								
Number	178	167	68	64	47	44	39	38
Average (oz.)	—	10.6	11.1	13.6	17.5	11.0	14.0	9.1
B								
Number	255	237	52	40	24	22	20	17
Average (oz.)	—	13.3	8.5	20.1	16.1	13.1	17.8	15.6
D								
Number	188	187	151	151	145	139	137	137
Average (oz.)	—	13.8	18.2	14.3	23.6	12.8	30.6	10.9

The superiority of plants from the genuine local stock (D) is clearly demonstrated by their survival and their high yield of hay. Another lot of local seed was obtained from another farm in 1929 and the better survival of this was beginning to exert itself during the past season.

In the first year or two the local seed has not exhibited much advantage over the others, but the lot included in the 1929-30 experiments is not believed to be as good as the one referred to in this table. It may be that this Vale seed, which was extensively cultivated before the War, has in the course of a century and a half undergone a process of adaption, and now contains a large number of plants which are long-lived and productive under local climatic conditions.

In 1925, the writer dug up sainfoin plants in a grass field which was reputed to have grown the genuine Vale of Glamorgan sainfoin and transplanted them to the experimental ground, where they still flourish. These plants must now be at least fifteen to twenty years old and possibly more.

IV. General review.

Of all the Common lots of French and Moravian origin tried, not one has approached the English lots in continued yield and persistency. The same is true of the Italian. The French appeared very much like Giant in flowering habit and aftermath development, although the French Common was more persistent; possibly it contained a proportion of long-lived plants. These

Continental plants are productive enough for the first year, but the chief point in growing sainfoin is that one looks for a crop which will yield a good crop for many years and hold the ground against weeds.

The English lots of Common may be placed in two divisions with regard to their permanency under South Wales conditions. This division has a geographical significance. The Eastern Counties generally are short-lived, and the yield of these plots falls off rapidly owing to the thinning out of the plants, whilst Hampshire and Cotswold and those of the adjoining counties are longer lived and show much less tendency to produce flower in the aftermath; their growth is also more prostrate. These lots differ somewhat amongst themselves, but it is evident that there are stocks which contain a high proportion of truly long lived plants. Evidence of this is also obtained from people who have known the growers. Mention has been made of lots obtained from the Vale of Glamorgan. There is no doubt that one of these is equal to any lot tried on our grounds in persistency and average yield of plants, thus supporting the local belief that home-saved seed of this is the best for local conditions. The writer has been told that in the Eastern Counties the growers keep to their local seed because of the greater expense of Hampshire, though admitting it to be more permanent and productive. From these data it may be argued, especially in view of reports from different parts of the world on red clover, that in the case of sainfoin also, there is a process of selection of physiological forms particularly suitable to the local conditions of climate and agriculture, and if that is so, it follows that possibly the forms that are most hardy and permanent in South Wales would not prove to be so in East Anglia or Moravia.

One of the main difficulties is that lots differ from farm to farm and Common stocks may easily become mixed by crossing with neighbouring crops of Giant. If improvement of stocks in the direction of permanency is sought for, the best stocks should be field-inspected in the aftermath stages and test plots established, then breeding work for yield can be commenced after elimination of undesirable plants from the best stock. The quest will never end.

V. Summary.

During the past six years lots of Giant and Common Sainfoin seeds have been obtained from France, Italy, Moravia, and from different English counties representing the seed usually available commercially in this country; also seed has been

collected locally in Glamorgan. Evidence is produced to show that a very permanent and productive local stock has been in existence in Glamorgan, and that the stocks best suited to South Wales conditions are those grown in the Cotswolds and south of the Thames, East Anglian lots being less permanent and Continental still less so.

VI. Acknowledgments.

Thanks are due to Messrs. J. P. Harvey, Kidderminster; Messrs. Leighton, Whitchurch, Salop; and Messrs. Dunn, Salisbury, for obtaining and presenting samples, also for much information.

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ITALIAN RYE-GRASS FOR WINTER KEEP.

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One of the chief difficulties which the farmer with a sheep walk has had to contend with during recent years is to maintain, through the winter, a sufficient supply of sheep to keep the mountain-land well grazed during the summer. This is particularly so in such counties as Merionethshire, where there is only a relatively small proportion of lowland ground in proportion to the mountains. Now that the trade for the three-year-old wether sheep has almost disappeared, the necessity for carrying the lambs through the winter has added to the farmers' difficulties, in so much as the old rough herbage which previously sufficed for the older sheep is now incapable of supplying the needs of the growing lambs.

The present method of bringing the lambs down in October to the lowlands has put a premium on the lowland areas. The result is that a very high price has to be paid for suitable lowland ground, thus in turn making it worth while for the lowland farmer to take advantage of every means of increasing the winter keep.

Recent investigations into the nutritive value of grassland have demonstrated that young pasture grass four to five inches long gives an analysis very similar to that of linseed cake.

Now farmers can keep their store cattle during the winter months with one feed of concentrates a day and the rest rough fodder. If this is so, why cannot sheep farmers grow a crop of winter hardy grass such as Italian rye-grass and turn the sheep into it for one feed a day and feed them for the rest of the twenty-four hours on the "ffriddoedd"[1] or other rough pastures?

With a view to testing this possibility, the experiment described in this paper was laid down in 1929.

A 3 acre field was selected. This field lent itself very well for dividing into plots, being long and narrow, so that only two short fences of about 40 yards in length were required to make three one-acre plots. This field had been down to grass for 7 to 8 years. It was ploughed in January, 1928, and sown with a crop of oats. In the spring of 1929 the stubble was ploughed up, cleaned, and manured with 5 cwt. to the acre of 32 per cent. slag. During the last week in April the field was well harrowed and rolled, and the whole field was seeded down with 40 lb. of Italian rye-grass and 2 lb. of wild white clover, at an approximate cost of 21*s*. per acre. Plots 2 and 3 were sown without a nurse crop, but in plot 1 rape was sown at the rate of 5 lb. to the acre, to compare the effect of using a nurse crop on the rye-grass sward and also to test the value of rape for fattening lambs.

On July 14, twenty wether lambs from the "ffriddoedd" were turned into the rape plot, and these were all sold fat before the middle of August. During the first week in August a light hay crop was taken from plots 2 and 3 of approximately 12 cwt. per acre. The aftermath of the three plots was grazed in conjunction with other fields, with ewes for flushing during September. On October 1 the three plots were closed up and manured with 1¼ cwt. to the acre of nitro-chalk. The autumn of 1929 was particularly mild, with a good deal of rain, and by Christmas the Italian rye-grass sward on the three plots had made very rapid growth for that time of the year, forming a thick sward about 6 to 8 inches high. There was no noticeable difference between the sward in plot 1, where rape had been used as a nurse crop, and the sward on the other two plots, which had been sown without a nurse crop. It was then decided that there was enough growth to start grazing. The next question to be decided was the number of sheep that could be safely used to graze for a limited period of two hours per day so that the rye-grass would last up to April 5, the usual date in these

[1] Enclosed land between the hill farm and the open hill.

parts for sending the yearling sheep up to the mountains. After some calculation it was decided to use thirty-five sheep for the experiment. These were a mixed lot, composed of some cull wether lambs, ewes, and a few rams. The culls had been grazed on aftermath throughout the autumn and had made very little progress.

On December 27 the thirty-five sheep were turned on to plot 1 for two hours a day, from 10 till 12 every morning, and grazed for the other twenty-two hours on a rough pasture or "ffridd". During the first few days the sheep were rather uneasy after being turned from the rye-grass, and endeavoured to find a way back, but after a week or so they settled down quite well to the routine. The first plot provided enough keep for the thirty-five sheep from December 27 to February 2.

The sheep were then turned into plot 2 for a similar period each day. The Italian rye-grass continued to grow during January and February and plot 2 produced enough keep for the sheep till March 14.

They were then turned into the third plot and grazed for the same period each day until April 5, when they were sent up to the mountains with the yearling sheep. At this date it was estimated that at least 50 per cent. of the keep available when the sheep were turned in on March 14 was still left. This and the second growth on the other two plots were used to graze some fifty ewes with their lambs.

The same method was used again for grazing the ewes and the lambs, but they were allowed three hours on the plots and instead of rough upland for the other twenty-one hours they had the run of some good pastures which, however, were grazed very bare. The ewes and lambs continued to graze on the plots till about May 1, when the plots were put up for hay. The question that then arose was whether the Italian rye-grass would give similar results during its second winter. Some of the authorities on this matter were consulted, but no definite information seemed available, so that it was decided to test this point, and the hay crop was left late before cutting from a hay standpoint in order to give the Italian rye-grass a chance of re-seeding.

The crop was cut late in July, and gave a yield of about 25 cwt. to the acre. The aftermath was grazed as in the previous year, and the plots were closed up on September 29 and dressed with 1¼ cwt. nitro-chalk to the acre, but the response to the manure and the rate of growth were very much less than in the first winter. At Christmas the plots were not promising enough to warrant carrying out the experiment on similar lines to those

of the previous year, and the field was grazed with the rest of the bottom land.

Another question now arose. The initial idea was that this field should be ploughed up in the spring of 1931 and put under rotation including a green crop, but on inspecting the field after grazing, a good deal of wild white clover could be seen mixed with the rye-grass, and as a sward of this nature was an unknown quantity to the writers, it was decided that the field should be grazed rotationally under the intensive system of grassland management in conjunction with the adjoining fields. By June, 1931, a marked improvement had taken place in the sward. Most of the Italian rye-grass had died down and the wild clover had increased enormously. A rough botanical analysis was made, giving the following results of percentage composition by weight :—

Wild white clover ...	... 75 per cent.
Italian ryegrass ...	... 10 per cent.
Miscellaneous species	... 15 per cent.

From a wild white clover point of view it was by far the best sward on the farm.

One great drawback of permanent grassland is seen in the lack of growth during the critical months of January, February and March, while leys newly sown down make quite an appreciable growth and at any rate remain quite fresh during these months. In practice, however, one finds that the more persistent species of plants generally sown in the seeds mixture do not possess this winter growing capacity to anything like the same extent as the short lived Italian rye-grass. The useful characters of Italian rye-grass have often been noticed by farmers in their newly sown hayfields. Full advantage, however, has not been taken of the benefits which Italian rye-grass sward may afford during the winter months. In the first place the Italian rye-grass, where present, is so palatable during the autumn months that the sheep when given free access to it nibble the grass so close and so often that by the critical period the plant is left not only without much growth, but also in a weakened condition, so that it is unable to take much advantage of any short intervals of mild weather which may occur during the winter months. In addition to this, the conditions for growth are so limited by temperature conditions that unless a plentiful supply of plant food is available in the ground the plant is hampered.

Conclusions.

(1) From the point of view of the upland sheep farmer, there seem to be distinct possibilities for evolving a system of growing a certain acreage of Italian rye-grass on fields contiguous to " ffriddoedd " and rough pastures. A farmer would then secure two objects : (*a*) He could winter a good number of his ewe lambs at home and, therefore, save a considerable sum of money on out-wintering. Some idea of the advantage accruing from the grazing of the Italian ryegrass may be obtained when it is remembered that were it not for those three acres of Italian rye-grass, at least twenty-five of the lambs would have had to be sent to " tack " at 7*s*. 6*d*. per head, this amounting to £9 7*s*. 6*d*. or £3 2*s*. 6*d*. per acre ; (*b*) He would at the same time be improving his rough pastures, and especially so, if he could fence small areas for this particular purpose. In many parts of the country there are large tracts of " ffridd " which are largely covered with bent and fine-leaved fescue ; both plants make fair growth in the summer and then become dried up in the autumn, with the result that there is a good deal of " feg " left on the ground over the winter. This " feg ", however, is incapable alone of carrying young stock, being deficient in protein and minerals, but will suffice to act as roughage provided a small bite of nutritious food is supplied in conjunction with it.

(2) *Effect on the sheep.*

Some of the cull lambs used in this experiment had been grazing on short aftermath from September till Christmas, and had made but little headway, but being rationed to one feed of rye-grass a day, for the period they appeared to thrive better, and all the sheep, while not fat by any means, looked very healthy and were in a thriving condition at the end of the experiment.

(3) *Number of sheep per acre.*

From the results obtained in this particular experiment, it seems safe to suggest that with a sward similar to the one obtained, forty Welsh lambs could be grazed for two hours a day on 8 acres.

(4) As it might not be a practical proposition to plough up the same field for Italian rye-grass every year, there seems to be an indication, from the quality of the sward in the summer of 1931, that a modification of the seeds mixture used, to include a small

proportion of perennial rye-grass, might also give a temporary grazing ley of high feeding value for a comparatively small outlay.

It is proposed to test this idea further in 1932. In assessing the value of this experiment it must be taken into consideration that the winter of 1930 was fairly mild and favourable to the growth of the sward; further work is needed over a number of years to secure more definite information.

(5) *Spring keep.*

It must also be taken into consideration that the Italian rye-grass sward not only gave a very high keep figure during the winter, but also gave a good quantity of early bite, which is a factor of great importance on sheep farms.

THE CHEMICAL COMPOSITION OF THE MISCELLANEOUS HERBS OF PASTURES.

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During the period 1930-1931 an investigation was conducted with the object of ascertaining the chemical composition of certain grassland herbs in the Province, which were known to be consumed by livestock. With the assistance of members of the staff of the Welsh Plant Breeding Station, specimens were obtained from both upland and lowland pastures, and while some species were more prevalent on the upland and *vice versa*, there were some that were common to both. It should be stated that all plants found in these pastures other than grasses and clovers are included under the term miscellaneous herbs. No attempt has been made to classify them, the investigation being wholly concerned with their chemical composition. A high proportion of the plants examined consisted of what are generally termed weeds. In this connection reference should be made to a valuable series of articles which have lately appeared in the *Journal of the Ministry of Agriculture* (1), where the author in his concluding paper gives a list of some three dozen plants " jotted down almost haphazard that may be regarded as the worst of grassland weeds ". It is of interest to note that a number of plants contained in this list are common in the pastures surveyed and dealt with in this article.

It is well known that the leaves of certain herbs are consumed and relished by stock, and that under certain conditions some are eaten in preference to grass. Thus during the late autumn and winter months, in pastures where bent predominates, the leaves of daisy, cat's-ear, and ribgrass are eaten in preference to bent (*Agrostis*), while others are eaten when "keep" is scarce. Analysis shows that the nutritive value of some of these plants is high, judged by their chemical composition, but this is found to vary greatly, depending upon a number of factors and in particular on the age of the plant. This is well illustrated in Table I.

TABLE I.

Composition of the dry matter of Woodrush (*Luzula campestris*), Tufted scirpus (*Scirpus caespitosus*) and Sowthistle (*Sonchus olearaceus*) sampled at different dates.

Species.	*Date of sampling.*	*Crude protein.*	*Fibre.*	*Ash.*	*Silica free ash.*
Woodrush	27/5/30	12.42	27.10	7.25	6.71
,,	9/7/30	7.96	29.09	5.97	4.62
Scirpus	4/6/30	11.76	29.00	4.94	4.70
,,	1/7/30	10.89	31.98	4.82	4.59
Sowthistle	26/5/31	19.99	16.42	12.10	10.12
,,	27/7/31	11.72	23.33	9.32	9.14

Species.	*Date of sampling.*	*Lime* (CaO)	*Phosphate* (P_2O_5)	*Potash* (K_2O)	*Chlorine* (Cl)
Woodrush	27/5/30	0.36	0.58	3.32	1.10
,,	9/7/30	0.55	0.38	2.47	0.78
Scirpus	4/6/30	0.26	0.62	3.39	0.71
,,	1/7/30	0.25	0.45	2.13	0.39
Sowthistle	26/5/31	1.93	1.03	3.81	2.34
,,	27/7/31	2.13	0.91	3.55	1.91

These results indicate that herbs deteriorate in composition with advancing maturity and resemble grasses in this respect. For example, a difference of fourteen days in the age of grasses has been found to have very striking effects on their chemical composition (2). While the actual difference in age of the herbs in Table I is greater than in the grasses referred to, the fall in protein and the rise in fibre of the sample of scirpus in a month is quite pronounced, and in sowthistle, where the difference in age is two months, the fall in crude protein and rise in fibre is over 40 per cent. The mineral content of herbs and grasses is similarly affected with advancing maturity, that is, the phosphoric acid, potash and chlorine content falls, and the lime content increases.

It has been observed that livestock exercise a certain amount of selection not only in their grazing but also in the portion or part of the plant they consume. Sheep, for instance, show a marked partiality for the leaf of some herbs, and for this reason are useful in suppressing certain species of weeds on the farm, since the constant nibbling of the young leaf checks its growth. This selection of the leaf by the sheep in preference to other portions of the plant may be entirely due to the palatability of that part of the herb, but analysis shows the leaf to be far superior to the stem in chemical composition as shown in Table II.

TABLE II.

Composition of the dry matter of the flowering stem and leaf of the daisy (*Bellis perennis*), Plantain (*Plantago lanceolata*) and Sorrel (*Rumex acetoscella*).

Species.	*Part of plant.*	*Date of cutting.*	*Crude protein*	*Fibre*	*Ash*	*Silica free ash*
Daisy ...	Stem	23/4/30	14.30	18.66	9.33	8.92
	Leaf		16.78	12.84	14.53	13.11
Plantain ...	Stem	30/4/30	15.36	22.87	8.70	7.61
	Leaf		20.25	14.84	12.17	11.72
Sorrel ...	Stem	16/5/30	18.27	21.27	10.87	10.28
	Leaf		27.03	17.40	15.00	13.66

Species.	*Part of plant.*	*Date of cutting.*	*Lime (CaO)*	*Phosphate (P_2O_5)*	*Potash (K_2O)*	*Chlorine (Cl)*
Daisy ...	Stem	23/4/30	1.24	1.17	2.96	1.10
	Leaf		1.75	0.91	3.11	2.84
Plantain ...	Stem	30/4/30	0.74	1.26	2.64	0.14
	Leaf		2.25	1.07	3.37	2.27
Sorrel ...	Stem	16/5/30	0.59	1.30	2.81	1.03
	Leaf		1.34	0.88	4.00	3.26

When judged by their chemical composition, the leaves of the above herbs are seen to be far superior to the flowering stem in

nutritive value, and differences in favour of the leaf over the stem of from 17 to 47 per cent. in crude protein are met with. These are typical of the majority of the herbs examined, and in addition, the flowering stem compared with the leaf contains from 20 to 50 per cent. more fibre. Of the mineral constituents, the percentage of lime, potash, and chlorine in the dry matter of the leaf is also much higher than the stem, the one mineral constituent in which the flowering stem is richer than the leaf being phosphate.

Many practical men attach considerable importance to the presence of certain herbs in grassland, especially if this is intended chiefly for grazing. In Elliot's system of laying down land to grass, narrow leaved plantain, yarrow and burnet formed a high percentage by weight of one seeds mixture successfully made use of at Clifton Park. Again, in certain districts of Wales narrow leaved plantain is greatly favoured especially in pastures grazed by sheep. Many farmers, from their own observations, know that ribgrass or narrow leaved plantain is relished by this class of stock, and in certain parts of the country is incorporated in the seeds mixture to ensure its presence in pastures grazed by sheep. It will be seen from Table III that valuable contributions are made to the mineral content of the herbage of pastures by the incorporation of such herbs, and this is probably the reason for the common practice of adding nettles, mangold leaves, turnip and swede tops to pigs' swill, as well as for the addition of nettles to poultry food.

TABLE III.

Average percentage of nitrogen, phosphoric acid, lime, potash, and chlorine in the dry matter of nettles, the leaves of mangolds, turnips, and swedes, and for comparison in wild white clover and Italian rye-grass cut as grass.

	Nitrogen (N)	*Phosphoric Acid* (P_2O_5)	*Lime* (CaO)	*Potash* (K_2O)	*Chlorine* (Cl)
Nettles ...	3.59	1.75	5.99	4.80	1.01
Mangolds ...	3.05	0.86	1.88	4.62	2.10
Turnips ...	3.11	1.27	3.18	2.64	1.18
Swedes ...	3.72	0.70	3.21	2.32	1.17
Wild white clover ...	4.56	0.61	2.92	2.20	0.26
Italian rye-grass ...	1.98	0.79	1.10	1.80	0.53

The figures given in Table III show that nettles and the leaves of mangolds, turnips and swedes are particularly rich in

nitrogen, lime, potash, and chlorine, and with the exception of nitrogen compare more than favourably with clover in all the constituents determined. All are far superior in nitrogen and mineral content to Italian rye-grass as well as grasses generally.

The percentage of lime in nettles is outstanding, and the practice of augmenting the food of pigs by nettles is a matter of considerable interest because the meals fed to pigs are usually low in lime. Again, the success following the use of nettles as a constituent of poultry food is undoubtedly partly accounted for by their richness in nitrogen, lime and phosphates.

Reference has already been made to the fact that it is the leaf portion of the herb that is generally consumed, and that at certain seasons of the year some herbs are eaten in preference to grass, while others are consumed when " keep " is scarce. It is known that such herbs as narrow leaved plantain (*Plantago lanceolata*), cat's ear (*Hypochoeris radicata*), daisy (*Bellis perennis*), dandelion (*Taraxacum*), heath rush (*Juncus squarrosus*) and certain species of sedge (*Carex*) are eagerly grazed in the autumn, winter and spring. The nitrogen and mineral constituents of these herbs are given in Table IV.

TABLE IV.

Average percentage of nitrogen, phosphoric acid, lime, potash, and chlorine content of the dry matter of narrow leaved plantain, cat's ear, daisy, dandelion, heath rush, and sedge.

	Nitrogen (*N*)	*Phosphoric Acid* (P_2O_5)	*Lime* (*CaO*)	*Potash* (K_2O)	*Chlorine* (*Cl*)
Plantain ...	3.09	1.07	2.25	3.37	2.27
Cat's-Ear ...	3.12	0.81	1.45	2.90	3.47
Daisy ...	2.67	0.91	1.75	3.11	2.84
Dandelion	3.09	0.98	1.80	4.09	2.00
Heath Rush	1.40	0.84	0.26	1.83	0.46
Sedge ...	1.17	0.80	0.19	1.85	0.31

Of the above herbs the first four are rich in nitrogen and lime, and particularly rich in chlorine. On the other hand, heath rush and sedge in chemical composition have no outstanding characteristics. However, they are winter green, which is an obvious attraction to sheep. Heath rush is one of the most heavily grazed plants at all seasons of the year, except when in flower, and the same may be said of the sedges (*Carex*).

Of the herbs found on upland pastures that are eaten by stock, ling (*Calluna vulgaris*) and bilberry (*Vaccinium Myrtillus*)

are probably among the most common, though bog asphodel (*Narthecium ossifragum*) is occasionally eaten.

The chemical composition of these herbs is shown in Table V, and for comparison, that of three grasses met with in these areas.

TABLE V.

Average percentage composition of the dry matter of ling, bilberry, bog-asphodel, molinia, nardus and bent (*Agrostis*).

Species.	*Month when sampled.*	*Crude protein*	*Fibre*	*Ash*	*Silica free ash*
Ling ...	June	8.96	28.90	7.54	5.68
Bilberry ...	June	15.70	16.07	4.61	4.28
Bog-asphodel	October	7.41	40.58	5.97	5.59
Molinia ...	June	16.16	32.00	4.55	3.34
Nardus ...	June	10.47	32.10	4.50	3.10
Bent ...	June	14.64	25.50	6.73	5.20

Species.	*Month when sampled.*	*Lime* (CaO)	*Phosphoric Acid* (P_2O_5)	*Potash* (K_2O)	*Chlorine* (Cl)
Ling ...	June	0.51	0.34	1.04	0.07
Bilberry ...	June	0.75	0.77	1.97	0.14
Bog-asphodel	October	0.78	0.26	1.33	0.35
Molinia ...	June	0.23	0.42	1.58	0.35
Nardus ...	June	0.22	0.31	1.59	0.28
Bent ...	June	0.38	0.41	2.61	0.91

It should be emphasised that in the case of bilberry and ling it is the topmost shoots that are eaten, and the above figures refer to the composition of those portions of the two plants. Apart from bilberry, the composition of the grasses is seen to be richer in protein than the herbs, though the herbs are all richer in lime and in the case of bilberry, in phosphoric acid also.

Table VI gives the average chemical composition of the different herbs examined.

As already stated, it is mainly the leaves of these herbs that are eaten, and in Table VI, unless otherwise indicated, the composition given is that of the leaf. Attention has also been drawn to the difference in composition between the stem and leaf of certain herbs and to the outstanding chemical characteristics of others. For example, the high nitrogen and lime content of the dry matter of the leaves of nettles, dandelion

TABLE VI.

Average percentage composition of dry matter.

PLANT.	*Ether Extract.*	*Crude Protein.*	*True Protein.*	*Fibre.*	*Ash.*	*Soluble Carbo-hydrates.*	*Silica Free Ash.*	*Silica.*	*Lime (CaO).*	*Phosphate (P_2O_5).*	*Potash (K_2O).*	*Chlorine (Cl).*
Bilberry (*Vaccinium Myrtillus*)	7.17	15.70	13.95	16.07	4.61	56.45	4.28	0.33	0.75	0.77	1.97	0.14
Bog asphodel (*Narthecium ossifragum*)	4.50	7.41	5.51	40.58	5.97	41.54	5.59	0.38	0.78	0.26	1.33	0.85
Butter cup (*Ranunculus repens*)	5.84	16.22	13.82	16.76	6.38	54.80	6.09	0.29	1.32	0.76	2.07	0.88
Cat's-ear (*Hypochoeris radicata*)	4.61	19.55	15.92	21.06	14.64	40.14	14.09	0.55	1.45	0.81	2.90	3.47
Cowslip (*Primula veris*)	3.31	12.64	9.49	15.81	8.07	60.17	7.73	0.34	1.55	0.54	3.05	0.53
Daisy leaf (*Bellis perennis*)	3.60	16.73	12.77	12.84	14.53	52.30	13.11	1.42	1.75	0.91	3.11	2.84
Daisy stem (*Bellis perennis*)	5.14	14.30	9.66	18.66	9.33	52.57	8.92	0.41	1.24	1.17	2.98	1.10
Dandelion (*Taraxacum*)	5.19	19.36	11.04	17.13	15.50	42.82	14.48	1.02	1.80	0.98	4.09	2.00
Devil's bit (*Scabiosa succisa*)	5.63	12.86	11.32	21.42	10.99	49.10	10.55	0.44	1.23	0.63	2.81	0.50
Gorse (*Ulex europaeus*)	4.70	16.84	16.27	33.10	7.40	41.96	7.08	0.32	0.71	0.74	3.26	0.53
Hawk-bit (*Leontodon*)	3.83	18.62	13.34	18.82	14.64	44.09	12.86	1.78	2.38	0.90	1.80	1.88
Heather (*Erica Tetralix*)	6.68	9.71	5.07	35.98	4.01	43.62	3.56	0 45	0 87	0.32	1.46	0.67
Heath rush (*Juncus squarrosus*)	3.28	8.75	8.01	27.51	3.82	56.64	3.59	0.23	0.26	0.24	1.83	0.46
Hogweed (*Heracleum Sphondylium*)	4.71	20.07	17.45	15.50	14.49	45.23	13.68	0.81	1.72	1.01	5.07	0.82
Knapweed (*Centaurea nigra*)	6.71	20.16	14.26	19.02	11.87	42.24	10.22	1.65	1.56	1.08	4.05	2.20
Ladies' Bed-straw (*Galium verum*)	5.01	16.49	13.07	22.14	6.12	50.24	5.80	0.32	0.49	0.57	2.70	0.32
Ling (*Calluna vulgaris*)	7.83	8.98	8.14	28.90	7.54	46.75	5.68	1.86	0.51	0.34	1.04	0.07
Nettles (*Urtica dioica*)	3.48	22.44	19.68	32.67	19.52	21.89	16.78	2.74	5.99	1.75	4.80	1.01
Ox-eye daisy (*Chrysanthemum Leucanthemum*)	5.71	10.80	8.52	27.88	8.50	47.11	7.81	0.69	1.06	0.74	2.00	0.53
Plantain, Ribgrass (*Plantago lanceolata*)	4.42	20.25	18.12	14.84	12.17	48.32	11.72	0.45	2.25	1.07	3.37	2.27
Plantain (*Plantago maritima*)	3.97	9.01	8.75	17.16	28.36	41.50	26.38	1.98	1.22	0.50	2.71	3.41
Ragwort (*Senecio Jacobaea*)	5.15	17.01	13.46	21.54	12.05	44.25	10.17	1.88	1.36	0.52	3.17	1.70
Rush (*Juncus communis*)	2.41	8.09	7.61	28.40	2.61	56.49	2.44	0.17	0.16	0.26	1.11	0.21
Sedge (*Carex*)	4.76	7.37	6.24	30.19	4.35	53.33	4.24	0.11	0.19	0.30	1.85	0.01
Selfheal (*Prunella vulgaris*)	4.24	10.32	8.70	18.57	13.39	53.48	11.18	2.21	1.20	0.61	3.50	0.67
Sorrel (*Rumex acetosella*)	4.30	24.71	16.14	15.38	14.10	41.51	12.59	1.51	1.23	0.95	4.01	0.64
Sowthistle (*Sonchus olearaceus*)	5.47	17.76	12.62	20.83	15.01	40.93	13.86	1 15	2.10	1.12	3.21	1.70
Speedwell (*Veronica officinalis*)	5.84	12.60	9.62	22.90	8.26	50.40	7.20	1.06	1.35	0.86	2.54	0.28
Tormentil (*Potentilla Tormentilla*)	4.66	10.50	9.01	27.36	6 45	51.03	6.08	0.37	1.07	1.03	2.45	0.21
Tufted scirpus (*Scirpus caespitosus*)	3.84	9.48	8.13	31.40	4.85	50.43	4.39	0.46	0.25	0.44	2.42	0.46
Wild pansy (*Viola lutea*)	4.32	11.76	9.42	23.95	11.25	48.72	10.50	0.75	1.25	0.86	3.91	0.75
Woodrush (*Luzula campestris*)	3.56	10.19	7.37	26.59	6.61	53.05	5.85	0.76	0.46	0.48	2.89	0.90
Yarrow (*Achillea Millefolium*)	4.43	19.90	16.01	24.31	10.61	40.75	10.10	0.51	1.08	0.91	2.81	0.92

and plantain. However, reference to Table VI shows that many other herbs such as knapweed, hawkbit and hogweed compare more than favourably with grasses in their nitrogen and lime content, and in this respect more closely resemble clovers.

The object with which this work was undertaken was to ascertain, if possible, whether these herbs possessed any outstanding chemical characteristic that would account for the partiality shown by stock for them at certain seasons of the year. While winter greenness is an undoubted attraction and might account for the consumption of *Juncus squarrosus* and certain of the *Carex* species when " keep " is scarce, this does not account for the preference shown by stock for such herbs as the daisy, cat's-ear and rib-grass where " keep " is plentiful. Examination of Table VI shows that the characteristics of the leaves of most of the herbs consumed, and more particularly those sought for by stock, are richness in crude protein and mineral content, suggesting another example of the wise selection shown by stock in their grazing.

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CHEMICAL COMPOSITION OF VARIOUS WHITE CLOVERS AND OF ITALIAN RYE-GRASS.[1]

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The investigations recorded in this article are divided into two parts : (1) the effect of repeated dressings of nitro-chalk on the chemical composition of white clover cut periodically in such

[1] All the chemical analyses were conducted by Dr. T. W. Evans in the Agricultural Chemistry Department, University College of Wales, Aberystwyth—the material being supplied by the senior writer. The data presented have been abstracted by the senior writer from two unpublished theses by Dr. Evans.

a manner as to simulate pasture conditions, and (2) the chemical composition of the hay and aftermath of various types of white clover.

I. The effect of a nitrogenous manure on the chemical composition of four types of white clover and of Italian rye-grass cut periodically.

Although the primary object of these investigations was to determine the effect of the application of a nitrogenous manure on the chemical composition of white clover and Italian rye-grass, the data obtained also throw a great deal of light on the differences in chemical composition between the various types of white clover, and between the clovers on the one hand and the grass on the other.

The material was obtained from the experiment described on p. 168 of the current volume of this *Journal*. Four types of white clover, namely, English wild white, New Zealand wild white, New Zealand stubble white and Dutch white were included in this experiment. The seeds were sown in 1927 on duplicate plots at the rate of 10 lb. per acre with Italian rye-grass sown at the same rate. In February, 1928, all the plots received a dressing of basic slag at the rate of 6 cwt. per acre, while four of the plots received in addition periodic applications of nitro-chalk. The dressings per acre and dates of application of the nitro-chalk were :—

1928 : February 14, 2 cwt.; April 2, May 14, July 2, August 14 and October 1, ¾ cwt. per dressing.

1929 : May 10, 2 cwt.; June 9, July 9, August 18, and September 28, ¾ cwt. per dressing.

The plots were cut at intervals according to the amount of growth, five times during the first harvest year and four times during the second year, with the scythe and lawn mower.

At every cut samples were taken from each plot and separated into (1) white clover; (2) Italian rye-grass; and (3) unsown species. All the white clover samples from every plot and every cut were analysed separately, but the Italian rye-grass samples from the phosphate plots at each cut were pooled, as were those of phosphate plus nitrogen plots. No analysis was made on the unsown species.

Though the following constituents were determined—crude fibre, silica-free ash, lime (CaO), phosphoric acid (P_2O_5), crude protein, true protein, ether extract, potash and chlorine—in the interests of brevity we propose in this article to confine our attention entirely to the first five constituents mentioned. The results for these constituents are summarized in Tables I and II.

TABLE I.

Average percentage crude protein, crude fibre, silica-free ash, lime and phosphoric acid in the dry matter of the four white clovers and the Italian rye-grass from the phosphate (P) and phosphate + Nitrogen (PN) plots.

Year.	*Constituents.*	*English wild white clover.*		*New Zealand wild white clover.*		*New Zealand stubble white clover.*		*Dutch white clover.*		*Average for the four types of clovers.*		*Italian rye-grass.*	
		P	*PN*	*P*	*PN*	*P*	*PN*	*P*	*PN*	*P*	*PN*	*P*	*PN*
1928. First harvest year.	Crude protein ...	28.50	27.91	28.03	28.82	27.14	25.49	27.15	26.36	27.71	27.15	12.09	13.18
	Crude fibre ...	17.67	18.58	17.66	18.10	17.81	18.25	19.73	19.10	18.22	18.51	25.00	25.36
	Silica-free ash ...	9.06	9.27	8.88	9.23	8.52	9.26	8.85	8.33	8.83	9.02	6.04	6.27
	Lime (CaO) ...	2.927	2.926	3.078	3.058	3.013	2.993	2.898	2.629	2.979	2.902	1.089	1.083
	Phosphoric acid (P_2O_5)	0.616	0.662	0.571	0.576	0.674	0.681	0.630	0.615	0.623	0.621	0.798	0.642
1929. Second harvest year.	Crude protein ...	24.03	23.75	24.55	23.75	22.98	22.66	21.74	21.48	23.31	22.91	11.25	12.09
	Crude fibre* ...	22.17	22.99	23.48	22.98	23.37	22.59	23.35	24.52	23.09	23.27	32.68	30.86
	Silica-free ash ...	9.48	9.42	8.91	9.51	9.36	9.32	8.71	9.23	9.12	9.37	6.88	6.73
	Lime (CaO) ...	2.979	2.906	3.286	2.877	3.084	2.918	2.968	2.772	3.079	2.868	1.330	1.253
	Phosphoric acid (P_2O_5)	0.910	0.772	0.926	0.712	0.850	0.659	0.870	0.810	0.889	0.738	0.744	0.657

* Averages for the last three cuts only.

TABLE II.

Seasonal variations in the percentage of crude protein, crude fibre, silica-free ash, lime (CaO) and phosphoric acid (P_2O_5) in dry matter of white clover and Italian rye-grass. The white clover results are those for the P plots of English wild white, while the data for Italian rye-grass represent the average results for all the P plots.

Year.	*Date of cuts.*	*Yield per acre lb. air-dried fodder.*		*Crude protein.*		*Crude fibre.*		*Silica-free ash.*		*Lime (CaO).*		*Phosphoric acid (P_2O_5).*	
		White clover.	*Italian rye-grass.*	*White clover.*	*Italian rye-grass.*	*White clover.*	*Italian rye-grass.*	*White clover.*	*Italian rye-grass.*	*White clover.*	*Italian rye-grass.*	*White clover.*	*Italian rye-grass.*
1928. First harvest year.	Apr. 24	6.2	206.8	31.15	14.62	10.64	18.20	7.45	5.60	2.590	1.019	0.489	0.966
	May 28	83.2	581.7	28.46	8.03	17.20	21.50	9.71	4.60	3.668	1.050	0.242	0.596
	July 2	123.2	278.5	25.51	13.13	22.40	32.65	11.28	6.85	3.080	0.980	0.919	0.626
	Aug. 18	224.4	290.8	28.31	9.63	19.20	24.95	7.45	5.10	2.536	0.833	0.524	0.742
	Oct. 11	80.5	276.3	29.05	14.87	18.90	27.68	9.40	8.03	2.760	1.561	0.907	1.062
	Average	—	—	28.50	12.09	17.67	25.00	9.06	6.04	2.927	1.089	0.616	0.798
	Relative	—	—	100.00	42.4	100.00	141.5	100.00	65.6	100.000	37.2	100.000	128.1
1929. Second harvest year.	May 9	24.5	148.1	22.40	12.72	16.92	21.21	10.10	6.41	3.584	1.232	0.655	0.556
	June 14	215.4	203.6	23.23	9.40	19.26	33.32	10.63	6.15	3.556	1.260	0.888	0.822
	Aug. 7	373.4	113.0	22.31	8.79	25.48	33.81	7.57	6.04	2.142	1.442	0.966	0.906
	Sept. 20	258.8	163.2	28.17	14.08	21.78	30.90	9.60	8.90	2.632	1.384	1.129	0.693
	Average	—	—	24.03	11.25	20.86	29.81	9.48	6.88	2.979	1.330	0.910	0.744
	Relative	—	—	100.00	46.4	100.00	142.9	100.00	70.4	100.000	44.6	100.000	81.7

Crude protein.

It will be seen from Table I that the average protein content of the white clovers was much higher in 1928 than in 1929. Italian rye-grass also gave somewhat similar results, though the difference between the two crops was not nearly as great as in the case of the clovers. As the plots were mown five times in 1928, but only four times in 1929, it is very probable that the lower protein content of the second year produce was at least partly due to the fact that the crops in that year were rather more mature when they were cut.

As shown in Table I all the white clovers were much richer in crude protein content than Italian rye-grass: in 1928 the average protein content of Italian rye-grass (Table II) was only 42.4 per cent., and in 1929 only 46.4 per cent. that of English wild white clover. The seasonal variation in percentage protein was greater in Italian rye-grass than in white clover. For instance, in 1928 the percentage protein in the grass which in April was 14.62 fell to a minimum (8.08) in May, rose abruptly in July to 13.13, to fall again suddenly in August to 9.63, then finally rose in October to 14.87; in the same season the protein content of English wild white decreased gradually from 31.15 per cent. in April to 25.51 in July, then rose again to 29.05 per cent. in October. The great disparity in the protein content of white clover and Italian rye-grass during the period of maximum growth was even more pronounced in 1929 than in the previous year. During the early and late parts of the season the clovers contained approximately twice as much protein as the Italian rye-grass, but in the two mid-season cuts the protein content of the clover was nearly three times as much as that of the grass.

It is rather significant that the two wild white clover types—English wild white and New Zealand wild white—were very similar in regard to their percentage protein content, both being appreciably richer than New Zealand stubble and Dutch white clover in this very important constituent. In 1928 there was practically no difference in this respect between the New Zealand stubble and Dutch, but in 1929 the latter was rather poorer in protein.

In all the clovers the protein content reached its highest peak in the spring; it then gradually decreased until it reached a minimum in July or August—the period of maximum growth of the white clover—then rose again as the season advanced. This mid-season depression in protein content was much more marked in the New Zealand stubble white and Dutch white than in the two wild white clovers.

The application of nitrogenous manure appears to have but very little effect on the protein content of the white clover. The slight increase in this constituent obtained from PN plots in the early part of the season was counterbalanced by a slight depression in the later part of the season.

In contrast to the clovers, the protein content of the Italian rye-grass was slightly increased as a result of the application of nitro-chalk.

Crude Fibre.

There is no doubt from the percentage figures shown in Table II[2] for English wild white clover (the results for the other three clovers were of the same general order as those given by English wild white) and Italian rye-grass that the grass and the clover were not only much richer in protein but also contained considerably less fibre in the first year than in the second year. In 1928 the plots were mown five times, but in 1929 they were cut only four times. The fact that in 1929 the grass and clovers were in a rather more matured stage of growth at each cut may

Year.	*Period of growth.*	*No. of days.*	*Average of all clovers.*			
			Per cent. protein.		*Per cent. fibre.*	
			P	*PN*	*P*	*PN*
1928	July 2 to Aug. 18	47	26.98	26.79	20.50	20.65
1929	June 14 to Aug. 7	54	21.71	21.18	26.60	27.68

Year.	*Period of growth.*	*No. of days.*	*Italian rye-grass.*			
			Per cent. protein.		*Per cent. fibre.*	
			P	*PN*	*P*	*PN*
1928	July 2 to Aug. 18	47	9.68	9.28	24.95	19.50
1929	June 14 to Aug. 7	54	8.79	11.42	33.81	30.34

[2] Average 1928 and 1929 figures for crude fibre are not comparable. The 1928 data represent the average results of all five cuts made that year, while the 1929 data represent the average for the last three cuts only, as the fibre content of the first cut from some of the plots was not determined.

partly explain the poorer quality of the produce in that year. The results given below, which represent the percentage crude protein and percentage crude fibre in the clovers and Italian rye-grass during approximately the same periods in 1928 and 1929, seem to suggest that the disparity in the quality of the first and second year crops was not entirely due to the differences in the stage of maturity of the produce.

At the beginning of the growing season the percentage fibre content of the clovers and Italian rye-grass was low, but increased rapidly up to about mid-summer, when it then gradually decreased.

Reference to Tables I and II shows that the fibre content of the grass was much higher in all cuts than that of the clover: the grass from the P plots contained in the first and second years respectively 41.5 per cent. and 42.9 per cent. more crude fibre than English wild white clover from the corresponding plot.

English wild, New Zealand wild and New Zealand stubble white clover had very similar fibre contents, and all three forms proved on the average to be rather less fibrous than Dutch white clover.

The application of nitro-chalk had no material effect in either season on the average percentage fibre in the clovers. It had also no effect in the first year on the fibre content of the Italian rye-grass, but seems to have had a slightly depressing influence on this constituent in the second year.

Silica-free ash.

Table II shows that all the white clovers were on the average richer in silica-free ash than the Italian rye-grass. As compared with English wild white on the P plot the grass had in the first year 65.6 per cent. and in the second year 70.4 per cent. less silica-free ash than the clover.

There appeared to be no significant difference between the four white clovers investigated in regard to their silica-free ash content.

Nitro-chalk had no material effect on the amount of ash in the clovers or Italian rye-grass.

Lime.

The lime content in white clover was comparatively low in the spring, but increased rapidly and remained uniformly high during May and June; it then dropped abruptly in July but recovered again towards the latter part of August to continue fairly high up to the end of the growing season.

All the clovers were far richer in lime in both seasons than the Italian rye-grass. Taking the average results for P and PN plots, the white clovers contained, in the first year, 269.4 per cent. and in the second year 229.8 per cent. more lime (CaO) than the grass.

The lime content of the two New Zealand forms was on the average slightly higher in both seasons than that of the other two clovers. Dutch white appears to be poorer in lime than English wild white clover.

The lime content of the clovers and of the grass was not affected to any appreciable extent in the first year, but seemed to have been slightly depressed in the second season by the application of nitro-chalk.

Phosphoric acid.

The percentage phosphoric acid in the clovers was appreciably higher in the second year than in the first, but Italian rye-grass showed no such inter-seasonal variation.

In the first year Italian rye-grass was slightly richer in phosphoric acid than the clovers, but in the second year the order was reversed, the clovers being on the average richer than the grass by 15.5 per cent.

There appeared to be no significant difference between the four white clovers in respect of their prosphoric acid content.

The application of nitro-chalk had no apparent effect on the percentage phosphoric acid in the white clovers in the first year, but seemed to have had a definitely depressing effect on Italian rye-grass in the first year and on both the clovers and the grass in the second year.

II. Chemical composition of the hay and aftermath of various white clovers during 1928 and 1929.

With the object of obtaining still more information concerning the chemical composition of various types of white clover, in 1928 and 1920 the hay and aftermath of a number of clovers, including the four types discussed in Part I of the paper, were analysed.

The material for these analyses was obtained from a yield trial[3] laid down in 1927, in which each lot was repeated three times. All the plots received in February, 1928, a dressing of basic slag at the rate of 6 cwt. per acre, but had no other manure.

[3] The yield results from this trial will be reported at an early date.

The plots were cut as hay and aftermath each year. Samples were taken from each plot at each cut and separated into clovers and grasses. For the purpose of chemical analysis the clovers from the three plots of each type were pooled.

The following constituents were estimated :—Crude protein, true protein, crude fibre, silica-free ash, lime, phosphoric acid, potash and chlorine; but owing to lack of space it will only be possible in this article to consider the most important of these constituents—crude protein, crude fibre, lime and phosphoric acid. However, it may be stated that the different clovers investigated showed but very little variation in regard to their silica-free ash, potash and chlorine content.

The percentage weights of these four constituents in the dry matter of the hay and aftermath of the clovers analysed are shown in Table III.

Since there was on the average in 1928 about 70 per cent. and in 1929 about 40 per cent. more white clover in the hay than in the aftermath, it is evident that the chemical composition of the hay gives a better indication of the real value of a clover than that of the aftermath, a fact which should be borne in mind when comparing the figures in Table III.

Crude protein.

In contrast to the grasses in which the protein content falls off rapidly as they reach maturity, as seen from Table III. the hay and aftermath of all the white clovers investigated are surprisingly rich in this constituent; the average protein contents in the hay and aftermath for all clovers in the first year were 19.76 per cent. and 28.88 per cent. respectively and in the second year 19.74 per cent. and 21.00 per cent. respectively.

In the hay cuts of both seasons English wild white was the richest and Dutch white the poorest in crude protein content, while the six New Zealand forms occupied an intermediate position in regard to this constituent.

Crude fibre.

In the hay and aftermath cuts of both seasons English wild white had the lowest percentage crude fibre and Dutch white the highest. With the exception of New Zealand stubble white, which was not very unlike Dutch white in this respect, the various New Zealand forms were again somewhat intermediate between English wild white and Dutch white in their fibre content.

TABLE III.

Showing the percentage crude protein, crude fibre, lime (CaO) and phosphoric acid (P_2O_5) in the dry matter of hay and aftermath of various forms of white clover for the seasons 1928 and 1929.

	Crude protein.				*Crude fibre.*				*Lime (CaO).*				*Phosphoric acid (P_2O_5).*			
	1928		*1929*		*1928*		*1929*		*1928*		*1929*		*1928*		*1929*	
	Hay 12/7	*Aftermath 10/10*	*Hay 10/6*	*Aftermath 21/8*	*Hay 12/7*	*Aftermath 10/10*	*Hay 10/6*	*Aftermath 21/8*	*Hay 10/7*	*Aftermath 10/10*	*Hay 10/6*	*Aftermath 21/8*	*Hay 10/7*	*Aftermath 10/10*	*Hay 10/6*	*Aftermath 21/8*
English wild white ...	22.27	22.39	21.21	20.51	21.85	19.00	15.72	24.05	2.814	2.814	2.880	1.792	0.725	0.944	0.548	0.799
Dutch white ...	17.50	23.49	18.11	19.99	25.39	22.98	18.05	28.25	2.408	3.080	2.086	1.988	0.703	0.885	0.584	0.858
New Zealand white ...	20.95	23.18	19.90	22.00	23.35	22.05	15.73	25.48	2.940	3.318	2.660	1.792	0.782	0.984	0.585	0.726
N.Z. large leaved ...	19.69	23.18	21.00	22.46	23.60	21.50	15.85	24.17	2.884	3.076	2.504	2.002	0.722	1.068	0.584	0.820
N.Z. ordinary ...	19.21	23.62	18.90	20.34	23.38	22.15	14.82	24.25	2.660	2.908	2.646	1.736	0.702	1.035	0.518	0.809
N.Z. stubble ...	18.94	24.10	19.33	20.69	24.38	20.22	17.10	26.92	2.744	3.136	3.066	1.904	0.671	0.999	0.589	0.836
Average ...	19.76	23.33	19.74	21.00	23.66	21.3	16.21	25.52	2.742	3.055	2.557	1.869	0.717	0.985	0.568	0.800

Lime.

The lime contents of all the clovers in the hay and aftermath of both seasons were exceptionally high. The averages for all the clovers in the first year were—hay 2.742 per cent. and aftermath 3.055 per cent., and in the second year, hay 2.557 per cent. and aftermath 1.869 per cent.

New Zealand wild white, New Zealand large leaved and New Zealand stubble white appear from these analyses to be decidedly richer in lime than any of the other clovers. In both seasons the lime content of Dutch white was comparatively very low in the hay crops and fairly high in the aftermaths. As regards this constituent, English wild white was on the average appreciably poorer than the New Zealand forms; it was, however, distinctly richer than Dutch white in the hay crops but rather poorer than the latter in the aftermaths.

Phosphoric acid.

In both years the aftermaths of all the clovers were consistently richer in phosphoric acid than the hay crops. There appeared to be no significant difference between the various forms investigated in respect of this constituent.

Summary and conclusions.

The following conclusions may be drawn from the results of the investigations reported in Part I of this paper on the chemical composition of Italian rye-grass and four white clovers, viz. :—English wild white, New Zealand white, New Zealand stubble and Dutch white, on plots which had been differentially manured and which were mown periodically for two years to simulate pasture conditions :—

1. Taking the average for the phosphate and phosphate + nitrogen plots for both seasons, the white clovers were 107.9 per cent. richer in crude protein, 37.0 per cent. richer in silica-free ash, 148.7 per cent. richer in lime and had 29.2 per cent. less crude fibre than Italian rye-grass. But the phosphoric acid contents of the clover and the grass were, on the average, very similar.

2. English wild white and New Zealand wild white were very similar in their crude protein content, both being rather richer in this constituent than New Zealand stubble, which in turn was slightly richer than Dutch white.

3. Dutch white clover had a rather higher crude fibre content than the other three clovers, which were very similar as regards this constituent.

4. There was no difference between the four clovers in percentage silica-free ash.

5. On the average the two New Zealand clovers had slightly higher lime contents in both seasons than the English wild white, while the results seem to indicate that the latter was rather richer in this constituent than Dutch white.

6. The four clovers were very similar in their phosphoric acid contents.

7. In the case of the white clovers the addition of nitro-chalk to phosphates had no effect on the percentage crude protein, crude fibre and silica-free ash in either season. The nitrogenous manure slightly depressed the lime and phosphoric acid contents of the clovers in the second year, though it had no significant effect on these constituents in the first year.

8. In the case of Italian rye-grass, nitro-chalk had no effect on crude fibre and lime in the first season and on crude protein and silica-free ash in both years. However, it slightly reduced the crude fibre and lime in the second season and the phosphoric acid in both years.

The following conclusions may be drawn from the results reported in Part II relative to the chemical composition of the hay and aftermaths of six types of white clover :—

1. In comparison with the grasses, all the white clovers investigated have very high crude protein and lime contents and low crude fibre contents in both hay and aftermath.

2. In the hay cuts of both years English wild white had the highest percentage crude protein and Dutch white the lowest.

3. Again in the hay and aftermath cuts of both seasons English wild white had the lowest crude fibre content, Dutch white the highest.

4. The New Zealand clovers, especially the wild, the large leaved and the stubble types, were particularly rich in lime. English wild white, though poorer than most of the New Zealand clovers, was definitely richer in lime than Dutch white in the two hay crops, but was rather poorer in the two aftermaths.

5. There was no significant difference between the various clovers as regards percentage phosphoric acid.

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EFFECT OF A NITROGENOUS MANURE ON WHITE CLOVER AND A COMPARISON OF THE PRODUCTIVENESS OF FOUR TYPES OF WHITE CLOVER UNDER SIMULATED PASTURE CONDITIONS.

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Introduction.

The experiment described in this article was undertaken with two main objects in view, namely, (1) to ascertain the relative productiveness of four types of white clover under pasture conditions, and (2) to determine the effect of nitrogenous manures on white clover.

The experiment was carried out at the Welsh Plant Breeding Station on light soil rather deficient in lime and phosphates. The types of white clover tested were: English wild white (Kent), genuine New Zealand wild white from a pasture forty years old, New Zealand stubble white which proved to be a typical New Zealand ordinary white, and Dutch white clover. The seeds were sown without a nurse crop in May 1927, at the rate of 10 lb. per acre on duplicate 1/200th acre plots with Italian rye-grass sown at the same rate. As might be expected from such heavy seeding, the initial takes of white clover on all plots was very thick.

Manuring.[1]

Basic slag containing 15¾ per cent. phosphoric acid was applied at the rate of 6 cwt. per acre to all plots in February, 1928. One series of four plots, which will hereafter be referred to as P plots, received no other manures. The other series, which will be referred to as PN plots, received, in addition, periodic dressings of nitro-chalk in 1928 and 1929. The composition of the nitro-chalk was: nitrogen 15.5 per cent., $CaCO_3$ 48.0 per cent., and CaO 26.9 per cent. The nitro-chalk was applied as soon as possible after each cut. The time and rates of application were as follows: 1928, February 14, 2 cwt. per acre; April 2, May 14, July 2, August 17, and October 1, ¾ cwt. per acre per dressing; 1929, May 10,[2] 2 cwt. per acre; June 9, July 9, August

[1] To ensure even distribution of the manures, both the slag and nitro-chalk were carefully weighed out for each plot.

[2] Through an oversight, the first dressing in 1929 was not applied until May 10.

18, and September 28, ¾ cwt. per acre per dressing. The plots received no artificials in 1930.

Treatment of Plots.

The plots were cut in September of the seeding year and then kept ungrazed until the following spring. In 1928 and 1929 (the first and second harvest years respectively), the plots were cut with the scythe and lawn mower approximately every five weeks throughout the growing seasons, but in 1930 they were cut only twice—as hay and aftermath. In the case of the pasture cuts, the total produce of each plot at each cut was air-dried and weighed. The proportions of white clover, Italian rye-grass, and unsown species in each cut were determined on samples taken from the air-dried material. In the case of the 1930 hay and aftermath cuts, the air-dried weights were determined on samples taken from the weighed green produce.

In discussing the results obtained, it is proposed first to consider the effect of nitro-chalk on the growth of the clover and grass constituents of the plots and then to compare the four white clovers tested in regard to their productiveness and permanence.

The results are summarized in Tables I and II.

The effect of nitrogen.

(1) *White clover.*

As may be seen from the results shown in Table I, the initial effect of nitro-chalk was to stimulate the growth of white clover; in the May cut of the first harvest year the PN plots contributed 17.8 per cent. more clover than the P plots. But in the latter part of the season the nitrogenous manure had quite an opposite effect; the white clover contribution of the PN plots in the August cut was 10.6 per cent. less, and in the October cut 33.8 per cent. less than that of the P plots. If the total yields of the four clovers for 1928 are compared (Table I) it will be seen that plots receiving nitrogen + phosphate produced 8.1 per cent. less white clover than the plots which received only phosphates. Reference to Table II shows, however, that in the first harvest year the response of the different clover types to repeated dressings of nitro-chalk was extremely variable; the nitrogenous manure, while it had very little effect on the clover content of the New Zealand stubble white and English wild white plots, reduced the clover yield of the Dutch white plots by 38.2 per cent. and increased that of New Zealand wild white by 11.6 per cent.

The effect of nitro-chalk on white clover was far more pronounced in the second harvest year than in the first. In 1929 the PN plots of all four types gave considerably less clover in all cuts than the P plots. Taking the total clover yields of the year, nitrogen depressed the contributions of English wild white by 25.5 per cent.; of New Zealand wild white by 87.9 per cent.; of Dutch white by 89.1 per cent., and of New Zealand stubble white by 59.4 per cent.

As already stated, no manures were applied to these plots in 1930. It is evident from the clover yields of that year that the harmful effect of the nitrogenous manure on white clover

TABLE I.

Average weights (lb. of air-dried fodder per acre) of (1) white clover; (2) Italian rye-grass and (3) unsown species yielded by the phosphate and phosphate + nitrogen plots at each cut.

Date.	*Date of cut.*	*White clover.*		*Italian rye-grass.*		*Unsown species.*		*Total.*	
		P	*PN*	*P*	*PN*	*P*	*PN*	*P*	*PN*
1928. First harvest year.	Apr. 24	10.6	8.4	206.8	254.7	1.0	6.2	218.2	269.3
	May 28	121.4	143.0	581.7	634.5	144.3	245.5	847.4	1023.0
	July 2	140.8	137.3	278.5	333.1	41.8	107.8	461.1	468.2
	Aug. 18	162.8	145.6	290.8	302.1	35.6	96.4	489.3	545.2
	Oct. 10	130.2	86.2	276.3	228.4	30.4	85.4	436.9	400.0
	Total	565.8	520.5	1634.1	1753.8	253.1	541.3	2453.0	2815.7
	Percentage P Plots = 100	100.0	91.9	100.0	107.2	100.0	213.9	100.0	114.7
1929. Second harvest year.	May 9	24.3	13.5	148.1	118.5	28.5	30.5	200.9	162.5
	June 14	247.1	126.7	203.6	168.2	743.8	1161.9	1194.5	1456.8
	Aug. 7	288.3	215.3	113.0	93.2	125.7	296.0	529.0	605.5
	Sept. 20	156.5	83.2	163.2	96.0	225.2	265.0	544.9	443.2
	Total	716.2	438.7	627.9	476.9	1123.2	1753.4	2469.3	2668.0
	Percentage P Plots = 100	100.0	61.2	100.0	75.5	100.0	156.1	100.0	108.1
1930. Third harvest year.	Hay	468	239	1161	935	2113	2348	3742	3522
	Aftermath	156	97	268	98	785	763	1208	958
	Total	624	336	1429	1033	2897	3101	4950	4470
	Percentage P Plots = 100	100.0	53.9	100.0	71.5	100.0	107.0	100.0	90.1

TABLE II.

The aggregate yields (in lb. of air-dried fodder) of (1) white clover; (2) Italian rye-grass, and (3) unsown species from P and PN plots of English wild white, New Zealand wild white, New Zealand stubble white, and Dutch white clovers during each of the first three harvest years.

FIRST HARVEST YEAR (1928) YIELDS. FIVE CUTS.

Plots.	Treatments.	White Clover. Lb. per Acre.	White Clover. Percentages. Treatments P =100	White Clover. Percentages. Average Yields, Eng. W.W. Plots =100.	Italian Rye-grass. Lb. per Acre.	Italian Rye-grass. Percentages. Treatments P =100	Italian Rye-grass. Percentages. Average Yields, Eng. W.W. Plots =100.	Unsown Species. Lb. per Acre.	Unsown Species. Percentages. Treatments P =100	Unsown Species. Percentages. Average Yields, Eng. W.W. Plots =100.
English Wild White Clover	P	517.4	100.0		1625.8	100.0		260.5	100.0	
	PN	480.0	92.6		1771.9	109.0		410.5	157.6	
	Average	498.7		100.0	1698.8		100.0	335.5		100.0
N.Z. Wild White Clover	P	647.2	100.0		1722.6	100.0		217.8	100.0	
	PN	732.2	111.6		1753.4	101.7		478.3	219.5	
	Average	689.7		138.3	1738.0		102.3	348.0		103.7
N.Z. Stubble White Clover	P	576.5	100.0		1553.2	100.0		299.2	100.0	
	PN	543.8	94.3		1317.1	84.8		783.5	261.8	
	Average	560.1		112.3	1435.1		84.5	541.3		164.3
Dutch White Clover	P	523.2	100.0		1635.9	100.0		234.5	100.0	
	PN	323.4	61.8		2173.6	132.8		491.0	209.4	
	Average	423.3		84.9	1904.7		112.1	362.7		108.1

SECOND HARVEST YEAR (1929) YIELDS. FOUR CUTS.

Plots.	Treatments.	White Clover. Lb. per Acre.	White Clover. Percentages. Treatments P =100	White Clover. Percentages. Average Yields, Eng. W.W. Plots =100.	Italian Rye-grass. Lb. per Acre.	Italian Rye-grass. Percentages. Treatments P =100	Italian Rye-grass. Percentages. Average Yields, Eng. W.W. Plots =100.	Unsown Species. Lb. per Acre.	Unsown Species. Percentages. Treatments P =100	Unsown Species. Percentages. Average Yields, Eng. W.W. Plots =100.
English Wild White Clover	P	872.3	100.0		853.8	100.0		1440.2	100.0	
	PN	650.3	74.5		495.9	58.1		1919.8	133.3	
	Average	761.3		100.0	674.8		100.0	1680.0		100.0
N.Z. Wild White Clover	P	1033.2	100.0		696.1	100.0		1046.6	100.0	
	PN	641.0	62.1		525.8	75.5		1481.4	141.5	
	Average	837.1		109.8	610.9		90.5	1264.0		75.2
N.Z. Stubble White Clover	P	596.8	100.0		590.1	100.0		1091.1	100.0	
	PN	242.4	40.6		432.4	73.3		1977.7	181.2	
	Average	419.6		55.1	511.2		75.8	1534.4		91.3
Dutch White Clover	P	363.0	100.0		371.3	100.0		914.9	100.0	
	PN	221.2	60.9		453.7	122.2		1642.9	179.5	
	Average	292.1		38.3	412.5		61.1	1278.9		76.1

THIRD HARVEST YEAR (1930) YIELDS. HAY AND AFTERMATH.

Plots.	Treatments.	White Clover. Lb. per Acre.	White Clover. Percentages. Treatments P =100	White Clover. Percentages. Average Yields, Eng. W.W. Plots =100.	Italian Rye-grass. Lb. per Acre.	Italian Rye-grass. Percentages. Treatments P =100	Italian Rye-grass. Percentages. Average Yields, Eng. W.W. Plots =100.	Unsown Species. Lb. per Acre.	Unsown Species. Percentages. Treatments P =100	Unsown Species. Percentages. Average Yields, Eng. W.W. Plots =100.
English Wild White Clover	P	956	100.0		1584	100.0		2008	100.0	
	PN	616	64.4		818	51.6		2118	105.4	
	Average	786		100.0	1201		100.0	2063		100.0
N.Z. Wild White Clover	P	800	100.0		1768	100.0		1980	100.0	
	PN	602	75.2		1200	67.8		1484	74.9	
	Average	701		89.2	1484		123.5	1732		83.9
N.Z. Stubble White Clover	P	440	100.0		1150	100.0		1856	100.0	
	PN	12	2.7		1326	115.3		2502	134.6	
	Average	226		28.7	1238		103.1	2179		105.6
Dutch White Clover	P	300	100.0		1216	100.0		804	100.0	
	PN	116	38.6		788	64.8		1646	204.7	
	Average	208		26.4	1002		83.4	1225		59.4

persisted even after the dressings had been discontinued. The P plots gave in the third harvest year nearly twice as much white clover as the PN plots.

(2) *Italian rye-grass.*

In considering the effect of nitro-chalk on Italian rye-grass, it is important to bear in mind that we are dealing not with a true pasture plant but with a comparatively short-lived and essentially hay plant.

As might have been expected, the general tendency of nitrogenous manure was to encourage the growth of Italian rye-grass in the first harvest year, though it must be admitted the increased yield (7.2 per cent.) from the PN plots was much less than was expected.

In the second harvest year, the yields of Italian rye-grass on the PN plots of English wild white, New Zealand wild and New Zealand stubble were reduced, as compared with those obtained on the corresponding P plots, by 24.5, 26.7, and 41.9 per cent. respectively, but on the PN plots of Dutch white the Italian rye-grass actually gave an increased yield of 22.2 per cent.

Reference to Table II will show that the P plots of the three clover types which gave an increased yield of Italian rye-grass contained in the second year not only much more clover than the corresponding PN plots but also considerably more clover than the P plot of Dutch white. Since the P plots had a much better stand of white clover, it is evident that the accumulations of nitrogen resulting from the activities of the nodule-forming bacteria were much greater on those plots than on the PN plots. It is also clear for the same reason that the P plots of English wild white, New Zealand wild, and New Zealand stubble must have been richer in nitrogen than the P plot of Dutch white. Although the data available are admittedly too meagre to allow any definite conclusions to be drawn from them, nevertheless the yield results strongly suggest that the P plots of the English wild, New Zealand wild, and New Zealand stubble contained, as a result of the activity of nitrogen-fixing bacteria, sufficient available nitrogen to meet the requirements of Italian rye-grass, but that the amount of available nitrogen on the P plots of Dutch white was inadequate for this purpose.

In the third harvest year there was a slightly increased yield of Italian rye-grass (15.8 per cent.) on the New Zealand stubble white PN plot, which was not nearly enough to compensate for the very considerable reductions that occurred on

PN plots of New Zealand wild white (82.2 per cent.), Dutch white (85.2 per cent.), and English wild white (48.4 per cent.).

(8) *Unsown species.*

Except in the case of the Dutch white plots and to a rather less extent of the New Zealand stubble white plots, which contained quite a fair amount of miscellaneous weeds, more especially daisies and crowsfoot, the greater part of the produce categorized as unsown species consisted of *Agrostis* spp. and rough-stalked meadow grass.

The influence of repeated applications of nitro-chalk on the spread and growth of unsown species was very remarkable. On the average, PN plots yielded in the first harvest year 113.9 per cent., in the second year 56.1 per cent. more " unsown species " than the corresponding P plots (Table I). It is interesting to note that this increase fell to 7.0 per cent. in the third year after the dressing of nitrogen was discontinued.

From the results obtained there does not appear to be the least doubt that in the experiment under review repeated doses of nitro-chalk had a markedly depressing influence on white clover. The results do not lend any support to the view widely held that nitrogenous manures have no effect on the growth of white clover except in so far as they increase the competition to which the clovers are normally subjected in pastures by stimulating the growth of the top grasses. It is sometimes argued that this can be readily remedied by careful management and judicious grazing. It seems very probable from observations made on this and other similar experiments that nitrogenous manures have in addition to this indirect effect a more direct action on the growth of white clover. The results in fact suggest that the direct action of the nitrogenous manures is even more important than their indirect effect. In this experiment the shading effect of the grasses could not have been unduly severe as at no time during the first two years was the growth allowed to exceed four or five inches. Except during the first two or three months in 1928, the white clover plants on the P plots were visibly stronger and more robust than on the PN plots, and this was reflected in the greater rapidity with which the clover on the P plots recovered and started fresh growth after being cut.

Comparative productivity of the four white clover types tested.

The data given in Table II are interesting. They show *inter alia* that in the first harvest year (1928) the heaviest yields of white clover were obtained from the New Zealand wild white

clover plots; New Zealand stubble white took second place, and English wild white third, while Dutch white was a poor fourth. If the yields are expressed as percentages of that of English wild white, then the relative weights of air-dried clover obtained in the first harvest year from the P and PN plots of each of the four clover types tested were: English wild white 100; New Zealand wild white 138.3; New Zealand stubble white 112.3, and Dutch white 84.9.

In the second harvest year (1929) New Zealand wild white again proved slightly more productive than Kentish wild, but New Zealand stubble white completely belied the good start it made in the first year, its yields in 1929 being hardly more than half that of English wild white, which it surpassed in 1928. Dutch white plots gave comparatively even much poorer yields than in the first year. The relative weights of air-dried clover yielded by the four clover types in the second year were: English wild white, 100; New Zealand wild white, 109.8; New Zealand stubble white, 55.1, and Dutch white, 38.3. As a matter of fact, the difference between English and New Zealand wild whites on the one hand and New Zealand stubble and Dutch white clovers on the other was actually greater than is indicated by these percentage figures, as the latter plots by the autumn of the second year had been recolonized to quite an appreciable extent by volunteer wild white clover.

New Zealand wild white, though it still continued to give quite good results, was surpassed for the first time by English wild white in the third harvest year. The New Zealand stubble white and Dutch white were about equally poor—the greater part of the clover yields obtained from these plots that year being contributed by volunteer wild white plants which were rapidly taking possession of the ground vacated by the sown species.

Summary.

The results of the investigations reported on in this article may be summarized as follows:—

(1) In the first harvest year nitro-chalk stimulated the growth of white clover in the early part of the season, but depressed the growth in the latter part of the year. The net result of the nitrogenous manure in the first year was to reduce the yield of white clover by 8.1 per cent.

(2) The effect of nitro-chalk on white clover was far more pronounced in the second harvest year than in the first. In that year it reduced the yield of English wild white by 25.5 per cent.; of New Zealand white wild by 37.9 per cent.; of New Zealand

stubble white by 59.4 per cent.; and of Dutch white by 89.1 per cent.

(3) The harmful effect of the nitrogenous manure on the growth of white clover was still evident in the third year even after the application of the manure had been discontinued. In that year the PN plots gave on the average 46.1 per cent. less clover than the P plots.

(4) The exact manner in which nitrogenous manures suppress white clover is still obscure. Though it is probable that the increased competition from the grasses may partly account for the reduced growth, it is not improbable that the manure may also have a direct effect on the clovers.

(5) The application of repeated dressings of nitro-chalk increased the yield of Italian rye-grass by a narrow margin (9.1 per cent.) in the first year. Its general tendency in the second year was to depress this grass.

(6) Nitro-chalk greatly stimulated the growth of unsown species (mainly *Agrostis* spp. and rough-stalked meadow grass).

(7) In the first harvest year, under a system of repeated cutting, New Zealand wild and stubble white clovers both out-yielded English wild white, which in turn proved considerably more productive than Dutch white.

(8) New Zealand wild white maintained its superiority over English wild white in the second year, but New Zealand stubble white and Dutch white clovers were much inferior.

(9) English wild white proved superior to its New Zealand counterpart in the third year, both these types being far more productive than the other two types despite the fact that the plots had become to a considerable extent recolonized by volunteer wild white plants.

THE YIELD AND RESPONSE TO MANURES OF CONTRASTING PASTURE TYPES.

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Introduction.

On the valley bottom farmlands of the Aberystwyth district on soils which are derivatives of glacial drifts or of more recent alluvial deposits the making of a high-grade pasture is fairly

easy, for when they are seeded down, and subjected to reasonably sound pasture management, they can generally be stabilised at what may be termed the rye-grass standard, that is to say, they will carry a pasture complex in which perennial rye-grass, rough-stalked meadow grass and white clover will be important constituents and will be supplemented by considerable proportions of crested dogstail, cocksfoot, and in certain cases a telling amount of meadow fescue, tall fescue, timothy and meadow foxtail. As a general principle, the greater the aggregate proportion of the foregoing species in the herbage of any one of these comparatively good old pastures, the better the stock-carrying capacity of that pasture. Perennial rye-grass in association with white clover is in itself a pivotal species, and it can rightly be said that the greater the percentage of rye-grass in a pasture the more remunerative as a grazing unit is that pasture likely to be. Looked upon as an agronomic problem, therefore, anything that is done to increase the proportion of rye-grass and its group associates in a pasture automatically improves that pasture, and if the cost of improvement is low enough, the pasture becomes more remunerative to the stock owner. Where the high relative cost of improvement is not warranted by the returns and does not warrant the attempt to retain the botanical composition of the pasture at the rye-grass standard, we have to look for a new standard of floristic composition at which to aim. Nature herself points very clearly to the answer; she stabilises her second-class soil types at what may be described as the *Agrostis*-white clover standard, and where bent (*Agrostis vulgaris*) provides the main bulk of gramineous herbage supported in great measure by sweet vernal, fine-leaved fescue, Yorkshire fog and sometimes with minor quantities of cocksfoot, dogstail, rye-grass and rough-stalked meadow grass. White clover usually provides the bulk of leguminous growth often with wild red clover, *Lotus corniculatus*, *Lotus major* and yellow suckling clover. There is evidence to indicate that our ideals in pasture stabilisation should be centred around these two major pasture groups, the rye-grass and its associates on ploughable land situated at elevations up to 500 ft. and land of even higher elevation which will hold rye-grass well. On the hill grazings, now so often dominant, *Nardus*, *Molinia*, sheep's fescue, bracken and *Calluna*, a class of pasturage where there is a particular paucity of legumes, *Agrostis* and white clover would appear to be the most remunerative pasture complex towards which goal all efforts in modification of existing practice should be aimed. On the run-out lowland pastures, the legumes

are usually sufficient, or if deficient can usually be increased by systematic manuring and improved management, but there is need for a drastic change over in the personnel of the existing grass species, which is often only possible by ploughing out and re-seeding. On the best hill grazings, on the other hand, the gramineous content may often be easily and economically improved, but it is only possible to establish white clover on the sward by sowing the seeds and assisting establishment by appropriate cultivating operations and the application of suitable manures for that purpose.

The Experiment (E.96; E.85).

Preliminary experiments were started in 1927 on various sward and soil types occurring in the Aberystwyth area, and these have been reported upon by Stapledon and Thomas (1).

In 1928 the present series were planned on the same principle and the work was carried out in 1929-30. As far as possible similar types of grassland were dealt with in the two series of trials, namely (*a*) good lowland permanant pasture containing rye-grass as an inherent constituent; (*b*) inferior lowland pasture, but containing some rye-grass, and in reality being an outrun rye-grass pasture; (*c*) temporary ley on good lowland soil; (*d*) temporary ley on thin lowland soil; (*e*) hill intake pasture typical of its class in the district; (*f*) open hill fescue pasture; (*g*) open hill *Molinia* pasture; (*h*) a fescue-*Armeria* estuarine salting (Dovey estuary); (*k*) a lowland semi-marsh pasture at 800 ft. The present report deals with the available data collected during 1929 on these several grassland types; references will be made throughout the paper to the results obtained in the 1927 and 1928 trials.

Material and Methods.

Six plots were dealt with at each of six centres and three plots at each of the three remaining centres; the plots were everywhere 6 ft. × 6 ft. and the whole area dealt with at each centre was enclosed by a single fence. The plots were arranged respectively in one or two rows of three inside this fence, a 8 ft. border was allowed between each plot and 2 ft. all round inside the fence. By this means any border effect that might occur was eliminated. Only the areas within each square of 6 ft. × 6 ft. were critically analysed. The treatment of the plots was as follows in the main trial[1] :—

[1] In the three plot subsidiary trial at three centres treatments were control, P and PN only.

(1) Control (C) = no manure.

(2) Lime (Ca) in the form of calcium carbonate applied in one dressing at the rate of 5 tons per acre in the early spring of 1929 (7th February).

(3) Phosphate (P) as superphosphate (16 per cent. P_2O_5) applied at the rate of 4 cwt. per acre in one spring dressing (4th March).

(4) Potash (K) as kainit (20 per cent. K_2O) applied in one dressing at the rate of 4 cwt. per acre (7th February).

(5) Nitrogen (N) as nitro-chalk (15½ per cent. N_2) applied at the rate of 6½ cwt. per acre per annum. The nitro-chalk was applied in eight dressings approximately monthly throughout the summer.

(6) Complete manure (CaPKN) consisting of lime 5 tons, superphosphate 4 cwt., kainit 4 cwt. and nitro-chalk 6½ cwt. all in terms of per acre. This plot therefore received the full complement of manures applied in exactly the same manner and on similar dates as on each of the other plots.

All defoliation was carried out by means of clippers, and the cuts were advisedly made near to ground level and were, therefore, extremely drastic, more drastic than they would normally be in heavy sheep grazing.

The clippings were made as near as possible to the first day of each month. Winter growth was allowed to accumulate and was cut in the following May. After cutting, the grass from each plot was placed in scrim bags, such as are in general use at the Station, and air-dried to a constant weight. All weights were calculated on the air-dried material; this involves less error than does the taking of green weights, particularly in a wet climate such as obtains in West Wales, where, even in reasonably dry weather, heavy dews would tend to invalidate any serious attempt at making accurate estimates of the green weight.

Before making the pasture cut a botanical analysis was conducted on each plot by taking ten readings at random with the usual 6 in. × 6 in. mesh. The percentage productivity (*i.e.*, percentage by weight) is estimated, ten marks are given at each reading, and these marks are allotted to each species present in that reading in proportion to their estimated relative abundance (by weight).

Discussion of Results.

In the trials previously reported upon by Stapledon and Thomas (1) the manures were used largely in combination, while in the present series of trials the manures have been used

singly as well as in combination. It should be pointed out that these trials were not designed to test one form of manure against another, but were planned rather to test the effect of what may be termed the major plant nutrients (calcium, phosphoric acid, potash and nitrogen) upon the yield and botanical make-up of existing swards. The sward types under examination have designedly therefore been in sharp contrast the one to the other.

The yield and response to manures : (*a*) *gross yield.*

Table I shows the total yield of eatables obtained from each of the centres under review for the season May, 1929, to April, 1930. By " eatables " is meant green fodder that might be expected to be eaten by grazing stock, the amount of " eatables " being calculated on the gross air-dried produce less the amount of moss, burned leafage and earthy material that naturally aggregates in a closely cut sample of herbage. It will be seen from Table I that on all the swards under examination there has been considerable manurial response, but that by far the greatest response has been due to the complete dressing of lime and artificials. There has been a suppression of gross yield due to the application of potash in two instances, on one lowland centre (Centre C) and one upland centre (Centre E), in the latter case probably a significant decrease of 17 per cent. The average increase due to potash, taking into account the data for all six centres at which this manure was tested singly is only 5 per cent., and while this confirms previous experience of the manurial effects of potassic manures on grasslands in the Aberystwyth district, yet detailed consideration of the evidence before us shows that potash does give significant and probably payable increases in some instances in this area. For example, there was a 9 per cent. response to potash at Centre A (temporary ley) in 1929, but the potash response on these plots during the summer of 1931[2] is outstanding, particularly in its effect on the white clover content. The following statement taken on the 21st of August, 1931, will serve to illustrate the position :

		Total relative growth.		*Relative proportion white clover.*
CaPKN	...	110	...	5
N	..	60	...	5
P	...	15	...	10
Ca	...	15	...	10
K	...	100	...	100
C	...	15	...	10

[2] The treatment on these plots has been continued during 1930 and 1931, but no critical data have been collected on them during these seasons.

The data in respect of the potash plot are placed at 100 both regarding total growth and proportion of white clover. These data are presented to show that specific examples do occur where potash may be essential even in a district where normally potash will hardly repay its use on grassland. In 1929, the first year of treatment, the potash plot contained on the average of the season 28.1 per cent. white clover, compared with only 16.7 per cent. where superphosphate was applied, and 19.9 per cent. on the untreated plot.

TABLE I.

Showing the gross yields of eatables in cwt. (=100 lb.) per acre and the relative yields with control (unmanured) = 100 on six contrasting pasture types. Season 1929–30.

Type of pasture.	Centre.		CaPKN	N	P	Ca	K	Control.
A temporary ley on good lowland soil.	Centre A:	Actual	81.2	60.9	51.9	56.0	53.5	49.0
		Relative	166	124	106	114	109	100
A good lowland permanent pasture.	Centre B:	Actual	78.8	66.6	57.3	50.7	47.6	46.4
		Relative	170	143	123	109	102	100
An inferior lowland pasture.	Centre C:	Actual	58.8	29.8	28.2	23.5	21.7	22.6
		Relative	260	132	125	104	97	100
A temporary ley on thin lowland soil.	Centre D.	Actual	53.6	17.6	40.6	34.7	35.5	27.8
		Relative	193	171	146	125	128	100
Hill intake pasture.	Centre E:	Actual	39.7	27.8	20.5	21.1	17.0	20.4
		Relative	195	136	100	103	83	100
Open hill fescue pasture.	Centre F:	Actual	34.5	12.0	13.4	20.8	12.3	11.2
		Relative	308	107	120	181	110	100

Referring again to Table I, there has been significant increase at most centres due to the heavy application of lime (5 tons per acre of carbonate). The response is most marked (181 per cent.) on the open hill fescue pasture, and this degree of response to liming is being confirmed by other trials now in progress on this sward type.

The responses obtained after dressing with superphosphate have not come up to expectation, particularly when it is recognised that the grasslands of West Wales as a whole are deficient in phosphate and normally are highly responsive to such dressings : superphosphate was used throughout these trials, but even so it is doubtful if the full effect of any phosphatic dressing is felt during the first year. On the hill intake centre (Centre E) there has been no measureable effect upon total yield due to the phosphate dressing. This is somewhat surprising, as this sward contained legumes in reasonable amount (7.8 per cent. on the untreated plot and 12.4 per cent. on the phosphate plot).

In part, no doubt, the low relative responses to phosphates are consequent upon the fact that these are applied periodically to most pastures in the district, and it is highly probable that all the swards under review in this paper, with the exception of the open hill grazing, would have had dressings of phosphates at one time or another during the past decade. It is certain that the hill grazing has never been supplied with any such dressing.

The responses from simple dressings of nitrogen have been very striking at all the centres. The effect of the complete manurial dressing has been most marked, the increases ranging from 166 per cent. to 308 per cent., with the control at 100. The figure of 308 per cent. on the open hill grazing is of the magnitude of increase found in the earlier trials of the series already reported upon (1). These data show how depleted in available soil nutrients the upland pastures of Wales tend to be; this can, of course, be judged empirically by observing the constituent species that make up the swards of our open hills and by comparing the botanical composition of the open hill pasture with the composition of camp lairs, that is to say, with the composition of the herbage constituting a hill top sheep camp. The latter is manured often to excess, but gives us a picture of what these hills could carry by way of herbage were there forthcoming the soil fertility conditions and the management generally conducive to its growth. The presence of such floral patches, really representing almost first-class lowland grazings so far as their botanical characteristics are concerned, show that the paucity of first-class leguminous and gramineous species on the hill pastures is due in part at least to factors other than climatic. It shows, too, that the rye-grass, cocksfoot, meadow grass and white clover pasture type can be made the ideal on the more favoured parts of those hills.

TABLE II.

Comparison of seasonal yields untreated and manured on (a) lowland permanent pasture; (b) lowland temporary ley, and (c) upland pastures. Yield expressed in cwt. (=100 lb.) per acre eatables air-dried. Season 1929. E. 96.

	May	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Winter*	*Total*
(*a*) *Lowland permanent pasture.*								
Average of Centres B and C.								
Control ...	7.2	8.1	3.6	8.5	2.0	1.7	4.6	35.70
CaPKN ...	14.2	15.0	8.0	12.5	5.4	3.5	10.2	68.80
Relative with control 100 ...	197	198	222	147	270	206	222	192
(*b*) *Lowland temporary ley.*								
Average of Centres A and D.								
Control ...	9.9	7.6	6.1	5.0	4.5	1.4	4.0	38.5
CaPKN ...	17.0	13.7	7.8	9.0	8.0	2.3	9.7	67.5
Relative with control 100 ...	172	180	128	180	178	164	242	175
(*c*) *Upland pasture.*								
Average of Centres E and F.								
Control ...	4.6	3.4	3.9	1.4	1.8	0.1	0.8	16.0
CaPKN ...	7.2	5.8	9.0	3.4	5.2	1.2	5.2	37.0
Relative with control 100 ...	157	171	256	242	289	1200	650	237

The yield and response to manures : (b) seasonal yields.

The data given in Table II show the seasonal yields on pasture of contrasting type, lowland and upland, both untreated and under manurial dressings.

It is in the first place interesting to note the higher average yields given by the temporary leys as compared with the old permanent pastures. Not only this, but the monthly yields are better sustained on the temporary pastures. Considering the data cover the season 1929—one that may be regarded in humid West Wales as an outstandingly dry year—the yields on the temporary pastures have been maintained remarkably well from month to month, and in this respect are less erratic than on the permanent grass fields. This is equally true when the results from manured plots are studied, and it would appear that heavy dressings of artificial manures are not able to correct the tendency to falling yield that may occur during mid-season consequent upon periods of physiologic or climatic stress. The temporary pastures have given earlier growth in the spring, and at that period have been

more responsive to manures than the permanent pastures. This introduces the question of the relation of botanical composition of a pasture to its capacity to respond to added manures. From all our observations it is emphasised that the most responsive species is that which will without manures make some growth under any given set of meteorological conditions.

The relation of seasonal yields on lowland and upland pastures respectively is noteworthy; Table II shows that whereas the lowland pastures are highly productive from May to September inclusive, the hill pastures make really active growth only during May, June and July.

TABLE III.

Showing the average percentage contribution of grasses, clovers, miscellaneous plants, and of moss plus " burn " in the herbage under different systems of manuring. Average of six centres. E. 96. Season 1929.

Treatment.	*Grasses.*	*Clovers.*	*Miscellaneous plants.*	*Moss plus " burn."*	*Total.*
CaPKN	82.9	2.9	13.0	1.2	100.0
N	77.5	2.9	17.7	1.9	100.0
P	67.3	10.8	20.0	1.9	100.0
Ca	68.1	7.4	22.6	1.9	100.0
K	67.9	7.7	22.0	2.4	100.0
Control	68.1	6.3	22.8	2.8	100.0

The effect of various manures on the botanical composition of the cuts.

Table III shows the average composition from all centres in respect of (1) grasses; (2) clovers; (3) miscellaneous plants, and (4) the sum of moss and burned leafage. The data relative to grasses indicate quite clearly that nitrogen has been the one single manurial ingredient which has turned the grass-clover balance definitely in favour of the grasses: this effect is even more emphatic under the complete manuring. Nitrogen has favoured the grasses at the expense of both the leguminous and miscellaneous species, nitrogen in effect may be looked upon as a grass food just as the phosphates are rightly looked upon as elements providing special feeding for leguminous herbage. So far as the trials under review are concerned neither lime nor phosphates nor potassic manures have had a significant effect upon the grasses relative to the total herbage.

Phosphates alone have throughout the trials acted in a normal manner, and, while increasing total bulk, have had a greater effect upon the clovers than upon other constituents of

the flora. Potassic fertiliser has on the average had but a slight effect upon the balance of sward constituents. To this there was one outstanding exception on the lowland temporary ley in its fifth harvest year (Centre A). At this centre white clover gave a remarkable response to potash, a response much greater than that given to phosphates. This result was even more marked in the third year of application (1931) and has been fully discussed above.

All the manures, individually and collectively, have tended to reduce moss and to lessen the contribution of burned and dead uneatable herbage; in other words, manuring tends to promote green and actively growing pasturage.

TABLE IV.

Comparing the yield and percentage contribution of grasses, clovers, miscellaneous plants and of moss plus "burn" on a hill intake pasture (Centre E) and a hill fescue pasture (Centre F) under six systems of manuring. Season 1929.

Treatment.	*Pasture type.*	*Yield during season.*	*Per cent. grasses.*	*Per cent. clovers.*	*Per cent. weeds.*	*Per cent. moss and burn.*
CaPKN	Hill intake	39.7	77.4	5.8	15.9	0.9
	Hill fescue	34.5	79.2	—	19.5	1.3
N	Hill intake	27.8	68.9	2.8	26.7	1.6
	Hill fescue	12.0	66.9	—	28.9	4.2
P	Hill intake	20.5	54.6	12.4	30.8	2.2
	Hill fescue	13.4	70.1	—	27.1	2.8
Ca	Hill intake	21.1	55.6	12.5	29.7	2.2
	Hill fescue	20.3	69.3	—	28.2	2.5
K	Hill intake	17.0	61.2	6.3	28.6	3.9
	Hill fescue	12.3	67.9	—	28.4	3.7
Control	Hill intake	20.4	53.4	7.8	35.1	3.7
	Hill fescue	11.2	61.8	—	32.6	5.6

Comparison of manurial effects upon botanical composition on the Hill Intake and the Open Hill Pasture.

Data of considerable interest are shown in Table IV. Normally the open hill grazings of Wales contain little trace of leguminous flora, and where any legumes occur they are very

sparse in their distribution and are virtually limited to a form of bird's foot trefoil (*Lotus corniculatus*) and to mountain vetchling (*Lathyrus montanus*). The hill intake farmlands, that is, lands that have been comparatively recently under the plough, contain appreciable quantities of wild white clover, wild red clover, *Lotus* spp. and yellow suckling clover. The open hill grasslands at their higher elevation have never been ploughed, but their lower slopes show signs of having been ploughed at some time or other, though in the majority of cases none of them have been under the plough subsequent to the Napoleonic wars.

The almost complete absence of clovers on the hill grazings is important, and suggests that any improvement in their stock-carrying capacity in the economic sense must be accompanied by the introduction of leguminous herbage into them. The clovers not only require minerals to thrive upon, but they are themselves minerally-efficient in the sense that they take up and store minerals in their tissues to a much greater degree than do any of our commoner grasses.

The data presented in Table IV were obtained from two pastures that are comparable in elevation and soil type and where the major distinction is consequent upon pre-treatment. The intake pasture standing at an elevation of 800 ft. above sea level has been ploughed and reseeded since the beginning of the present century and has almost certainly been dressed with basic slag during that period. It is unlikely, however, that any of the species sown in the seeds mixture when last laid out have maintained themselves in the sward, so that the floristic composition, while being in a way artificially induced, bears a much greater relation to the induced condition of the soil than to any effect set up by the seeds mixture.

Referring to the specific action of the various manures (Table IV) lime has had the greatest individual response on the hill, but complete manuring has had an even more marked effect. On the intake pasture, lime and phosphate have both had a marked effect upon the proportion of legumes, while nitrogen has had a depressant effect, which was not wholly righted by the addition of phosphates, lime and potash in the complete manurial dressing.

The response of various grasses to manures at contrasting type centres.

The summarised data given in Table V are compiled in respect of the four permanent pasture centres, two lowland and

two upland. Rye-grass, cocksfoot, dogstail and rough-stalked meadow grass have been arbitrarily grouped together as species demanding relatively high fertility, while Yorkshire fog, bent and fine-leaved fescue have been similarly grouped as species

TABLE V.

Showing the actual yield in cwt. (=100 lb.) per acre and percentage contribution and response to manuring of certain grasses; (a) the rye-grass group (high fertility-demanding) and (b) the *Agrostis* group (low fertility-tolerating). Four centres representing four permanent pasture types. E. 96. Season 1929.

Centre.	Pasture type.		C_aPKN	N	P	C_a	K	Control
(a) *Rye-grass group.*								
Centre B	Good lowland	Per cent.	74.6	63.8	56.4	51.1	54.0	52.2
		Actual	57.1	39.9	30.3	25.3	25.1	22.5
Centre C	Poor lowland	Per cent.	50.0	24.4	25.3	24.3	18.9	25.8
		Actual	28.1	6.0	6.2	5.0	3.6	5.4
Centre E	Hill intake	Per cent.	35.7	15.2	8.8	14.6	8.7	9.7
		Actual	11.8	3.7	1.8	2.2	1.0	1.6
Centre F	Hill fescue	Per cent.	—	—	—	—	—	—
		Actual	—	—	—	—	—	—
(b) *Agrostis group.*								
Centre B	Good lowland	Per cent.	11.4	15.8	13.4	11.0	20.5	21.3
		Actual	10.9	12.2	8.6	6.1	10.0	9.9
Centre C	Poor lowland	Per cent.	33.3	48.8	37.7	43.0	48.3	47.8
		Actual	21.7	17.1	11.7	11.6	11.2	11.4
Centre E	Hill intake	Per cent.	39.0	45.4	39.5	35.5	41.9	37.4
		Actual	16.5	12.8	7.8	8.0	7.2	7.7
Centre F*	Hill fescue	Per cent.	70.8	55.9	59.1	58.8	56.0	53.6
		Actual	23.6	6.5	7.4	11.8	6.3	5.6

* Including *Aira flexuosa* at this centre.

tolerating low fertility conditions. The responses of these species looked upon as two groups at the several contrasting centres is of fundamental interest.

On the lowland pastures where the rye-grass group form an important proportion of the untreated sward there was marked response to the higher manuring; at Centre B the proportion of this group increased from 52.2 per cent. on the unmanured plot to 74.6 per cent. on the complete manure plot, or in actual yield from 22.5 cwt. to 57.1 cwt. (Table V). The response to the single manures applied was intermediate in degree, nitrogen

having by far the greatest effect of any one manure. At the second lowland centre, Centre C, the proportion increased from 25.8 per cent. to 50.0 per cent., or in actual yield, from 5.4 cwt. per acre to 28.1 cwt. The response to the single manures applied, however, has been comparatively small at this centre, illustrating the need of complete manure on this type of land before much can be done by way of improvement in yield. The proportion of the *Agrostis* group at Centre B was on the average lowered by each of the manurial treatments, the complete manure having the greatest lowering effect; the actual yields, however, have not been very much affected. Similarly at Centre C, the effect of complete manuring shows a decrease in the proportion of the *Agrostis* group, but the actual yield shows an increase from 11.7 to 21.7 cwt. per acre. At the hill intake centre (Centre E) where rye-grass occurred only in small amount, dogstail was the grass which individually gave the greatest response to manuring, in proportion from 9.7 per cent. on the control to 34.7 per cent. on the complete manure plot; in actual yield from 1.6 cwt. to 11.8 cwt. per acre, and representing 15.2 per cent. or 3.7 cwt. of the herbage on the nitrogen-only plot. At this centre bent, Yorkshire fog and fine-leaved fescue were all in slightly increased proportion due to manuring, the actual yield of complete and nitrogen-only increased from 7.7 cwt. on control to 16.5 and 12.5 cwt. per acre respectively.

On the open hill pasture (Centre F) rye-grass, cocksfoot, meadow grass or dogstail did not occur, and addition of manures gave a decided increase in the proportion of bent and fine-leaved fescue, in the aggregate increasing from 53.6 per cent. to 70.8 per cent. of the total herbage, or in actual yield, from 5.6 cwt. to 23.6 cwt., a much greater relative increase than these species showed on the hill intake (Centre E) where they were in competition with considerable amounts of dogstail.

The foregoing results illustrate an important agronomic principle, namely, that high fertility-demanding species such as rye-grass, where present in a mixed pasture association, are able to give much greater responses to added manures than are the low fertility-tolerating species such as bent, fog and fine-leaved fescue. There is a growing volume of evidence to indicate that the high production species tend to suppress the bent group, and it would follow, therefore, that manuring can, within limits, change the floristic composition of a pasture.

A general statistical treatment of the data in Table V in respect of the three centres, B, C, and E, seems to confirm the

conclusions drawn in the last paragraph. In Tables VI and VII are shown the statistical treatments according to the method described by Fisher and Wishart (2).

TABLE VI.

Showing the statistical treatment of the rye-grass group.

ANALYSES OF VARIANCE.

Due to	*Degrees of freedom.*	*Sum of squares.*	*Mean square.*	*½ log.e (Mean square).*	*Difference.*
Blocks ...	2	3001.478	1500.739	3.65906	
Errors ...	10	259.675	25.967	1.62841	2.0307
Treatments	5	1130.105	226.021	2.71026	1.08185
Total ...	17	4391.258	—	—	—

Standard error (of total of 3) is 8.826 or 19.1 per cent.

(i) " Z " TEST.*

	Blocks.	*Treatment.*
	$N_1 = 2$; $N_2 = 10$.	$N_1 = 5$; $N_2 = 10$.
5 per cent. points ...	.7058	.6009
1 per cent. points ...	1.0114	.8646
Experimental values of z ...	2.0307 clearly significant	1.0818 significant

(ii) STANDARD ERROR TEST.

Variance of single plot	25.967
Variance of total of 3 plots	77.901
Standard error of total of 3 is $\sqrt{77.901}$	8.826
Standard error of one	2.942
Standard error of difference between two means = 2.942 × 1.414	4.16
Mean yield for three plots	46.1
Mean yield for one plot	15.57

MEAN YIELD OF TREATMENTS (RYE-GRASS GROUP).

	Control.	*K.*	*Ca.*	*P.*	*N.*	*CaPKN.*	*Mean.*	*Standard error.*
Air-dry weight of rye-grass-group in cwt. per acre ...	9.83	9.90	10.83	12.76	16.53	32.33	15.37	2.942

Standard error of a difference between two means = 4.16.

* Tables, Fisher, pp. 212 (3).

TABLE VII.

Showing the statistical treatment of the *Agrostis* group.

ANALYSES OF VARIANCE.

Due to	*Degrees of freedom.*	*Sum of squares.*	*Mean square.*	½ $\log_e$ (*Mean square*).	*Difference.*
Blocks ...	2	74.7774	37.3887	1.81070	
Errors ...	10	39.2944	3.9294	.68419	1.12651
Treatments	5	151.1826	30.9294	1.70458	1.02039
Total ...	17	265.2544	—	—	—

Standard error (of total of 3) is 3.43 or 10.2 per cent.

(i) " Z " TEST.*

	Blocks. $N_1 = 2; N_2 = 10.$	*Treatment.* $N_1 = 5; N_2 = 10.$
5 per cent. points ...	.7058	.6009
1 per cent points ...	1.0114	.8646
Experimental values of z ...	1.12651 significant	1.02039 significant

(ii) STANDARD ERROR TEST.

Variance of single plot	3.9294
Variance of total of 3 plots	11.7882
Standard error of 3 is $\sqrt{11.782}$	**3.43**
Standard error of one	1.14
Standard error of difference between two means = 1.14 × 1.414 = 1.61196	1.612
Mean yield for three plots	33.733
Mean yield for one plot	11.244

MEAN YIELD OF TREATMENTS (*Agrostis* GROUP).

	Control.	*K.*	*Ca.*	*P.*	*N.*	*CaPKN.*	*Mean.*	*Standard error.*
Air-dry grass in cwt. per acre ...	9.666	9.466	8.566	9.366	14.030	16.370	11.244	1.14

Standard error of a difference between two means = 1.612

* Tables, Fisher, pp. 212 (3).

In summarised form the statistical results obtained were as follows :—

Rye-grass group. The " Z " test indicates that the differences due to centres are clearly significant, and that the differences due to treatments are also significant. The standard error test, however, points to insignificance in comparison of single treatments, though the difference between control (unmanured) and CaPKN is clearly significant.

Agrostis *group.* The " Z " test indicates that the differences due to centres are significant, though not nearly as significant

as in the rye-grass group. Likewise, differences due to treatment are again significant but not quite to the same degree as in the rye-grass group. The standard error test points to insignificance in comparison of single treatments, though, as before, the difference between control and CaPKN is clearly significant, but not nearly to so high a degree as in the rye-grass group.

TABLE VIII.

Showing seasonal production in cwt. (=100 lb.) per acre air-dry weights of (a) rye-grass group of grasses and (b) *Agrostis* group of grasses. Comparison of untreated and complete manurial plots of good lowland pasture (Centre B); poor lowland pasture (Centre C), and on hill fescue pasture (Centre F).

Date.	Centre B.				Centre C.				Centre F.	
	(a) *Rye-grass* group.		(b) *Agrostis* group.		(a) *Rye-grass* group.		(b) *Agrostis* group.		(b) *Agrostis* group.	
	CaPKN.	*Control.*	*CaPKN.*	*Control.*	*C PKN.*	*Control.*	*CaPKN.*	*Control.*	*CaPKN.*	*Control.*
May ...	10.8	4.0	4.2	2.9	4.2	1.7	6.5	3.2	3.6	1.6
June ...	11.6	5.2	3.8	3.2	4.5	0.7	5.8	3.1	2.7	0.6
July ...	5.4	2.3	0.6	0.3	4.2	0.9	2.8	1.6	5.7	1.5
Aug. ...	11.9	4.3	1.1	2.0	5.2	1.3	3.8	2.4	2.4	1.0
Sept. ...	5.1	2.0	0.2	0.8	2.1	0.2	1.6	0.2	3.6	0.2
Oct. ...	3.2	1.2	0.4	0.3	1.8	0.4	0.6	0.4	*	*
Winter ...	9.1	3.5	0.6	0.4	6.1	0.2	0.6	0.5	5.2	0.5
Total for 12 months	57.1	22.5	10.9	9.9	28.1	5.4	21.7	11.4	23.6	5.6
Relative ...	254	100	110	100	520	100	190	100	415	100

* No botanical analyses available in respect of this date.

The influence of complete manures upon the seasonal and other production of high and low fertility-demanding grass species.

Table VIII has been compiled from data collected on a good permanent pasture on the lowlands (Centre B), a poor lowland pasture (Centre C), and on an open hill grazing (Centre F). The

monthly air-dry yields of rye-grass, cocksfoot, dogstail and rough-stalked meadow grass have been aggregated as forming the rye-grass group, and bent, fog and fine-leaved fescue have likewise been aggregated as the *Agrostis* group. The yields are expressed as cwt. (= 100 lb.) per acre. Direct comparison can be made in respect of complete manuring and the control (untreated plot).

The effect of complete manuring on the rye-grass group has been very marked at both Centres B and C. At Centre B complete manure has maintained production in this group at more than twice that of the control plot throughout the whole season, summer and winter, while at Centre C production has been maintained at five times that of the control plot. The production in the *Agrostis* group at Centre B has in general only been a little more than maintained by heavy manuring, also at Centre C the increase in produce is small compared with that of the rye-grass group. At the hill centre, production of the bent and fescue has been many times increased by the manures. The relative figures for the year's production in respect of the rye-grass group at Centre B are 254 for the complete as against 100 for the control, and at Centre C the figures are 520 as against 100 for the control. The relative figures for the *Agrostis* group at the former centre are 110 (complete manure) to 100 (control) and for the latter centre 190 to 100, while the comparable figures on the hills are 415 to 100. These data emphasise the fact that while low fertility-tolerating species are well able to take advantage of any improvement in the amount of available nutrients yet they may be suppressed entirely or in part when in competition with the stronger growing and higher fertility-demanding grasses belonging to the arbitrary rye-grass group.

Manurial responses on (1) *A poor, badly drained lowland field;* (2) *A typical hill* Molinia *pasture; and* (3) *A typical estuarine salting.*

Three centres are here dealt with, none of which represents any of the grassland types discussed in the earlier part of this report, but which, however, are representative of considerable tracts of country in Wales and Western Britain. Only three plots are involved at each centre, namely, control, phosphate and phosphate plus nitrogen, the respective dressings corresponding in amount to those discussed in the foregoing sections. In this section, however, results are available for two seasons, namely, 1929-30 and 1930-31; the manurial treatments being the same

for the second year in (1) and (3), but in the case of (2)—the typical hill *Molinia* pasture—no manure was applied in the second year (1930-31).

TABLE IX.

Showing the gross yield of eatables in cwt. (=100 lb.) per acre and the relative yields with control (unmanured) =100 on three contrasting pasture types. Average for 1929-30 and 1930-1.

Centre.		*PN*		*P*		*Control.*	
		1929	*1930*	*1929*	*1930*	*1929*	*1930*
Brook Field	Actual	44.2	20.9	39.1	19.3	32.4	16.8
	Relative	137	125	121	115	100	100
Llety (*Molinia*)	Actual	44.6	11.6	24.1	6.5	12.2	4.7
	Relative	365	244	197	136	100	100
Dovey Marshes	Actual	17.5	15.1	6.2	6.4	6.7	6.5
	Relative	258	232	91	99	100	100

(1) The first centre was on the Station Farm and on a wet, badly-drained field that had been down to grass for many years; this grassland as a type occupies a large acreage in Wales, and is an extremely difficult proposition to improve by normal methods.

Table IX shows the gross yield of eatables obtained during the seasons 1929-30 and 1930-1 from the three plots control, phosphate, and phosphate plus nitrogen. There was an average response to manures in the season 1929-30. In the second year the yields on all three plots had decreased to approximately half the yields given by each respective plot in the preceding year.

Table X shows the effect of treatment on the botanical composition. It can be seen that there has been a rapid deterioration in the pasture complex; the percentage of useful grasses has decreased to nearly half, while the percentage of weeds has been doubled. These facts indicate that while available soil nutrients may be adequate for the maintenance of high fertility-demanding species, yet unless the waterlogged nature of the soil can be improved by drainage of the surplus water, conditions are not amenable to the growth of the better grasses. It seems essential on this soil type to drain off the surface water before any permanent improvement in the floristic nature of the sward cover can be accomplished.

TABLE X.

Showing the effect of treatment on the percentage contribution by weight of certain grasses, clovers, and weeds on a poor, badly drained lowland pasture. Seasons 1929-30 and 1930-1.

Species.	*PN*		*P*		*Control.*	
	1929	*1930*	*1929*	*1930*	*1929*	*1930*
Rough-stalked meadow grass ...	29.9	8.2	10.6	3.7	9.1	3.5
Crested dogstail ...	17.1	7.8	19.3	15.5	16.2	19.5
Meadow fescue ...	3.1	1.7	2.1	1.1	3.4	0.2
Agrostis spp. ...	5.9	7.7	4.4	1.3	0.9	1.1
Yorkshire fog ...	3.3	5.1	11.1	2.2	11.1	2.9
Sweet vernal ...	5.0	1.1	12.6	5.9	7.1	3.1
Wild white clover ...	1.1	0.9	9.[illegible]	3.7	5.0	1.3
Other grasses* ...	2.7	3.3	0.7	1.0	3.6	0.6
Other legumes† ...	Trace	Trace	—	Trace	0.2	Trace
Juncus spp. ...	0.1	1.3	Trace	3.6	0.1	3.3
Carex spp. ...	1.3	9.1	1.6	5.9	1.6	5.6
Weeds‡ ...	28.5	51.7	25.8	53.9	38.6	56.7
Moss and inert matter ...	2.0	2.1	2.2	2.2	3.1	2.2
Total ...	100	100	100	100	100	100

* Perennial rye-grass, timothy, fine-leaved fescue, *Triodia.*
† *Lotus* spp. and red clover.
‡ *Scirpus* spp. *Ranunculus* spp. ragwort, *Cardamine pratensis*, *Sagina*, *Luzula*, daisy, mouse-ear chickweed, plantain, *Crepis.*

(2) The second centre was situated on a *Molinia*-dominant pasture that is typical of a very large area on the Welsh hills at elevations above 800 feet. There is definite evidence accumulating which would indicate that there is a fairly straightforward fertility relationship between the *Molinia* pasture and the hill fescue *Agrostis* pasture. Just as an enormous increase in fertility such as is found localised on the hillside sheep camp induces the growth of rye-grass and white clover on these patches, so a less pronounced increase of fertility on a *Molinia* infested area, if accompanied by efficient grazing control, will promote the growth of bent and fine-leaved fescue accompanied by a complete local suppression of *Molinia*.

In the present trial the manured plots, particularly those receiving nitrogen, showed a most remarkable floral change almost within a few weeks after the commencement of the manurial treatments. The original sward of almost complete *Molinia* with an occasional small plant of fine-leaved fescue and an occasional stunted plant of bent was transformed into what was tantamount to a typical hill fascue pasture. Continuous

drastic clipping each month rapidly decreased the *Molinia* even on the unmanured plot, but there was in that case little or no replacement by the fescue or bent. On the phosphate plot also there was comparatively little growth of fescue and bent, but on the phosphate plus nitrogen plot a thick carpet of these grasses was produced and, moreover, was maintained throughout the course of the experiment. This striking result is of fundamental

TABLE XI.

Showing the effect of manures on the botanical composition of a *Molinia* area (Llety). The figures are given as percentage estimated contribution to the total herbage produced per season. Seasons 1929–30 and 1930-1.

Species.	*PN*		*P*		*Control.*	
	1929	*1930*	*1929*	*1930*	*1929*	*1930*
Molinia ...	18.1	15.3	18.4	28.6	33.7	43.7
Fine-leaved fescue ...	23.9	33.2	46.5	19.6	33.2	21.9
Bent ..	58.5	40.9	16.5	26.5	3.0	5.1
Nardus ...	0.5	1.7	0.7	2.4	0.2	2.3
Weeds* ...	1.0	5.5	4.3	11.8	7.2	8.0
Moss and inert matter ...	3.0	3.4	13.2	11.1	22.7	19.0
Total .	100	100	100	100	100	100

* *Galium*, *Tormentilla*, bog Asphodel, *Luzula*, bilberry, *Carex* spp., milkwort.

significance since it indicates that the vast areas on our Welsh hills now dominated by the low value grasses *Molinia* and *Nardus* are amenable to treatment and can, and probably in past times have, carried more valuable pasturage. With long continued depletion of minerals and other plant nutrients removed by way of bone, wool and carcase, soil fertility has fallen below the standard demanded by the *Agrostis*-fescue group. It is highly probable that these hills can payably carry a much higher grade of vegetation than exists at present upon them. May we not yet see the time when we know how to clothe them with rye-grass, cocksfoot and white clover as a commercial proposition?

The yields from contrasting manurial treatments on the *Molinia* (Llety) pasture are given in Table IX, and it will be there seen that the increased production due to added manures is very striking, nitrogen plus phosphate giving practically three times as much keep as the untreated plot. In the second year there was a considerable decrease in the yield of all plots, illustrating the effect of drastic cutting. But even though no manure

was applied in the second year, the yield of nitrogen plus phosphate, though very much less than in the preceding year, was twice that of control (no manure). The change in botanical composition (Table XI) is, however, of even greater significance and is to be correlated with a much longer growing season, *Molinia*, in relation to even bent and fescue, having an extremely short season of growth, which in extreme cases is confined to the months of June and July.

(8) The third centre under test in this series is a typical estuarine salting situated on the tidal flood area of the river Dovey, north of Aberystwyth. These saltings provide valuable sheep grazings, and are characterised by the close continuous grazing to which they are subjected. The flora on the unmanured plot under consideration is predominantly non-gramineous, the most abundant plant being sea-thrift (*Armeria maritima*). There are also certain quantities of seaside fescue (*Festuca maritima*), seaside bent (*Agrostis stolonifera* var.), scurvy grass (*Cochlearia officinalis*), *Glaux maritima*, together with traces of sea aster (*Aster Tripolium*), sea arrow grass (*Triglochin maritimum*), and snake grass (*Lepturus incurvatus*).

There is complete absence of leguminous flora on these salt marshes. Table IX shows that in both 1929 and 1930 manuring with phosphates produced very little effect. Nitrogen plus phosphates produced a significant increase in yield in both seasons and there was a marked change in the botanical composition of the plot, this being transformed into a more or less completely gramineous sward where fine-leaved fescue and seaside bent were co-dominant and together formed over 90 per cent. of the sward. On the nitrogen-phosphate plot there was practically complete suppression of sea thrift, scurvy grass and other wide leaved plants, and a correspondingly marked increase in grasses and grass-like plants. There appears to be, therefore, a fertility relationship between the normal sea thrift association and the normal sea fescue-bent association on these saltings. These two salt marsh vegetational types often show up in marked contrast, but closer study reveals that there exists every gradation from the dominant sea thrift through the co-dominant thrift-fescue to the dominant grassy pasture. The evidence from the present series of manurial trials would seem to indicate that the amount of easily available plant food determines the relative balance of sea thrift and fescue respectively. Perhaps the most surprising comparative figures shown in Table IX are the very low yields obtained from the saltings pasture cuts. The yield from the

untreated plot is at a much lower level than even the poorest of the hill centres. This is a most surprising result, since these saltings are highly valued as sheep pastures for summer grazing and maintain breeding ewes and their lambs in excellent condition and are said to carry over a ewe and its lamb per acre during the summer months. This degree of stocking capacity does not seem to be confirmed by the yields obtained from clippings, and it would be most interesting to know how far the efficiency of these salt marshes is due to (1) the presence upon them of herbs very rich in minerals, and (2) their freedom from stock-diseases, particularly of the liver-fluke type.

Summary.

A study of the effect of increasing soil fertility on the yield and botanical composition of contrasted pasture types varying from a poor *Molinia* pasture to a good lowland permanent pasture has been made. On each pasture type it is shown that an increase in fertility results in an increase in the percentage contribution of the better grass species. On pastures containing a small proportion of the rye-grass group of grasses an increase in fertility results in a considerable increase in the percentage contribution of this group. This fact is of considerable importance when the seasonal growth of a pasture is taken into consideration. The rye-grass group has a longer growing season than the *Agrostis* group, and an increase in the percentage contribution of the former group results in a longer growing season, commencing earlier in the spring and extending later into the autumn. It has been shown also on the uplands how a *Molinia* pasture has been converted into an *Agrostis*-fescue pasture by increasing the fertility of the soil. On the other hand, on a poor and badly drained lowland pasture where, on account of the waterlogged nature of the soil, there was no response to added manures, it appeared that though an adequate supply of soil nutrients is available, unless the waterlogged nature of the soil can be improved by drainage, conditions are not amenable to the growth of the better grasses. The response to individual manures has also been studied. Of these, nitrogen produced the greatest response. The single result where there was a potash response is interesting in that it indicates that although Welsh soils are generally fairly rich in potash, specific examples do occur where potash manuring is beneficial.

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THE EFFECT OF MANURES ON THE NITROGEN AND MINERAL CONTENT OF THE PRODUCE OF CONTRASTING PASTURE TYPES.

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The distribution of the centres, arrangement of the plots, the manurial treatment of these and the influence of the manures on the yield and botanical composition of the herbage has already been discussed in the previous paper of this issue of the *Journal*. What follows is confined to a discussion of the influence some of these manures have had on the nitrogen and mineral content of the produce.

In 1927 and 1928 an investigation (1) was carried out by the Welsh Plant Breeding Station into the effect of manures on the nitrogen and mineral content of upland and lowland pastures. In this investigation, the manures were applied in combination, whereas in the one under review, each of the manures was applied separately.

The general conclusions arrived at in the 1927 and 1928 investigation were as follows :—

1. The application of phosphates and potash together resulted in an increase in the average percentage of

nitrogen and phosphoric acid content of the herbage at all centres both upland and lowland.

2. Though no lime as such was applied to the plots, the addition of phosphates and potash resulted in an increase in the average percentage of lime in the large majority of the plots.
3. The effect of applying nitrogen in addition to phosphates and potash was to depress the average percentage of phosphoric acid and lime, and at the lowland centres to depress even the nitrogen.

As already indicated in the previous paper of this issue there are in the present investigation three plots at each centre to which nitrogenous, phosphatic, and potassic manures respectively were applied. It is therefore of interest to compare the effect of these manures when applied separately with their effect when applied in combination as was the case in 1927 and 1928.

The results for the two lowland permanent pastures at Rhydmeirionydd and Nantsiriol are given in Table I.

TABLE I.

Average percentage of nitrogen, phosphoric acid, lime, potash, and chlorine in the dry matter of the herbage during the months, April to October, inclusive.

Plot.	*Nitrogen.* (N.)	*Phosphoric Acid.* (P_2O_5.)	*Lime.* (CaO.)	*Potash.* (K_2O.)	*Chlorine.* (Cl.)
RHYDMEIRIONYDD.					
Control ...	2.52	0.59	1.06	2.50	0.63
Nitrogen	2.86	0.55	1.16	2.70	0.75
Phosphate	2.95	0.94	1.50	2.76	0.60
Potash ...	2.51	0.60	1.08	2.72	0.75
NANTSIRIOL.					
Control ...	2.74	0.86	1.32	2.88	0.84
Nitrogen	2.79	0.71	1.31	2.89	0.81
Phosphate	2.88	1.05	1.58	2.91	0.87
Potash ...	2.61	0.94	1.23	3.08	1.24

The effect of applying nitrogen in the form of nitro chalk to these lowland pastures has in each case been to increase the nitrogen content of the produce, though this is much more pronounced at Rhydmeirionydd than at Nantsiriol. Its influence on the lime, as would be expected, is contrary to that experienced in 1927, when the source of nitrogen was nitrate of soda and sulphate of

ammonia, and at Rhydmeirionydd, the poorer of the two centres, it has resulted in slightly increasing this constituent. The phosphoric acid, however, on the addition of the nitro chalk is depressed, which is in agreement with previous results obtained with other nitrogenous manures.

The application of phosphate in the form of superphosphate owing to its influence on the clover of the herbage has increased the nitrogen content of the produce to a greater extent than the nitrogenous manure, the presence of clover as is well known having a very marked effect on both the nitrogen and lime content of the produce.

The potash applied in the form of kainit does not appear at these centres to have had an appreciable effect on any constituent other than potash and chlorine, both of which are increased as a result of its application.

On comparing the above results with those of 1927 and 1928, it may be said that on the whole, the effect of the manures applied separately confirm the results obtained when similar manures were applied in combination.

The results of the application of the same three manures to lowland temporary leys are shown in Table II.

TABLE II.

Average percentage of nitrogen, phosphoric acid, lime, potash, and chlorine in the dry matter of the herbage during the months, April to October, inclusive.

SPRING FIELD.

Plot.	*Nitrogen.* (*N.*)	*Phosphoric Acid.* (P_2O_5)	*Lime.* (*CaO*)	*Potash.* (K_2O.)	*Chlorine.* (*Cl.*)
Control ...	2.70	0.84	1.31	4.12	0.58
Nitrogen	2.97	0.73	1.10	4.29	0.47
Phosphate	2.94	1.02	1.41	4.46	0.45
Potash ...	2.84	0.83	1.24	4.48	0.64

CROSSWOOD.

Control ...	2.87	1.03	1.46	2.17	0.81
Nitrogen	2.98	0.91	1.51	1.76	0.82
Phosphate	2.83	1.20	1.68	1.67	0.72
Potash ...	3.05	0.99	1.59	2.51	1.32

The application of nitrogen in the form of nitro chalk has at both centres increased the nitrogen and depressed the phosphoric

acid content of the produce, but the carbonate of lime of the nitro chalk has had little, if any, effect on the percentage of lime.

The phosphate again partly due to its effect on the clover content of the herbage has increased the nitrogen of the produce of Spring Field, and at both centres has increased its phosphoric acid and lime content.

Kainit at both centres has increased the potash and chloride content of the produce, and at Crosswood through encouraging the clover it has in addition, had a very considerable effect on the nitrogen. The effect of the application of these manures on upland pastures are given in Table III.

TABLE III.

Average percentage of nitrogen, phosphoric acid, lime, potash, and chlorine in the dry matter of the herbage during the months, April to October, inclusive.

LLETY.

Plot.	*Nitrogen.* (*N.*)	*Phosphoric Acid.* (P_2O_5.)	*Lime.* (*CaO.*)	*Potash.* (K_2O.)	*Chlorine.* (*Cl.*)
Control ...	2.44	0.56	0.70	2.28	0.17
Nitrogen	2.90	0.48	0.94	2.59	0.22
Phosphate	2.40	0.64	0.75	2.46	0.21
Potash ...	2.48	0.52	0.71	2.57	0.75

FOEL.

Control ...	2.54	0.67	1.60	2.23	0.47
Nitrogen	2.87	0.68	1.51	2.09	0.55
Phosphate	2.80	0.95	1.88	1.95	0.50
Potash ...	2.50	0.70	1.82	2.54	0.54

The herbage at Llety is devoid of any clover and the effect of the manures on the nitrogen and mineral content of the produce is therefore in no way complicated by its presence. At the centres previously discussed, the application of the nitrogenous manure increased the nitrogen, but had little effect on the lime content of the produce. In the case of Llety, however, which probably stands more in need of lime than any of the other centres, the nitro chalk has had a considerable effect on its lime content.

The phosphoric acid in the form of superphosphate has quite a distinct influence on the phosphate content of the produce at both centres, and in addition, the lime content has been increased

as the results of its application. The influence of the superphosphate on the clover content of the herbage has already been referred to, and the manner in which this increase in clover directly influences the nitrogen content is readily seen on comparing the composition of the produce of the two upland pastures, Llety and Foel, the former of which contains no clover in the herbage.

The potash as kainit has again increased the potash content of the herbage and the chlorides of the kainit has had a very striking effect on the chlorine content of the produce, particularly at Llety.

It has to be borne in mind that these results were obtained in the first year of the application of the manures. The probabilities are that their effect, apart from that of the nitrogen, will be more pronounced in succeeding years. In the main, however, they confirm the results obtained in the work of previous years already referred to, *i.e.*, the effect of applying nitrogen as nitro-chalk has been to increase the nitrogenous constituents of the plant and to depress the phosphoric acid. The carbonate of the nitro-chalk has not in the first year had any very striking effect on the lime content of the herbage, though at Llety one of the upland plots in which no clover occurs in the herbage, its effect is quite pronounced. At the remainder of the centres its influence on the lime content is small, and at most of these it hardly counterbalances the depressing effect of the nitrogen.

The application of superphosphate at most centres has had a considerable influence on the clover content of the produce, and as clover is considerably richer in nitrogen and lime than the grasses, it is a matter of great difficulty to know how much of this effect is direct and how much is due to its influence on the clover. Judged by the effect of superphosphate at Llety, where no clover is present in the herbage, it would appear as if its direct effect was small.

Potash in the form of kainit has had a very considerable influence on the potash and chloride content of the produce at all centres, and at Crosswood through its effect on the clover it has increased the nitrogen content very strikingly.

REFERENCE.

1. Fagan, T. W., and Provan, A. L. The Effect of Manures on the Nitrogen and Mineral Content of Upland and Lowland Pastures. Series H, No. 11, Seasons 1921-1929.

SOIL SURVEY OF WALES.

PROGRESS REPORT, 1929-1931.

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The work of the Survey during the two years 1929-31 has been practically confined to North Wales. Mapping has been carried out in three areas, namely, Flintshire, the lower part of the Vale of Clwyd, and the Caernarvon district. The Caernarvonshire work consists mainly in rounding off areas mapped in previous years and we shall, therefore, confine our attention in the present paper to the Flintshire and Vale of Clwyd areas.

The principles underlying the Survey have been already set forth in the last Progress Report (this *Journal*, Vol. VI, 1930). It may be added that the same methods are now in use in other parts of Great Britain where surveys are being carried out. The work is correlated by means of a small committee appointed by the Ministry of Agriculture for this purpose.

East Flintshire.

Topography of area surveyed.

The area surveyed, approximately 125 square miles, is that part of Flintshire lying east of a line running from Bagillt on the coast to Pen-y-cloddiau in the Clwydian Range.

In outline, the area may conveniently be regarded as a system of ridge and valley lying in a direction N.W.-S.E. parallel with the coast. The Alyn-Wheeler valley, which extends throughout in this direction, divides the area into approximately equal portions. Between this valley and the coast, the land consists of a broad ridge extending from Halkyn Mountain in the north-west, which has an altitude of 1,000 feet, to Buckley. East of Buckley, the outline is that of broad, gently rolling slopes which merge gradually into the lowland plain along the eastern border. In the Halkyn district, the outline is mainly determined by the conformation of the country rock, whilst to the east the smoother features are those of generally deep glacial drifts. South of the valley, the outline is dominated by extensive slopes which culminate in Moel Fammau, which has an elevation of 1,800 feet, Moel Findeg and Nerquis Mountain.

The drainage of the area is effected by the Wheeler, and more extensively by the Alun and its tributaries.

Geology.

The rocks underlying the area and the associated drifts belong to three systems, namely, Silurian, Carboniferous, and Triassic.

The upland country along the west, lying in the Clwydian Range, is formed of roughly-cleaved Wenlock Shales with occasional bands of flaggy shale and fine-grained sandstones. The derived soils belong to the Powys Suite.

The Carboniferous Limestone in this area forms a broad upland ridge extending from Halkyn Mountain to Loggerheads. Only on the northern portion of this ridge, however, do we find soils derived wholly from limestone and belonging to the Gower Suite. Limestone detritus appears to be a prominent constituent of considerable areas of mixed drifts in this locality.

Millstone Grit, which is the parent material of the Bodkin Suite, occurs mainly in the form of drift, extensive areas of which occur in the Tryddyn district and along the eastern flank of the Halkyn upland. In the former area, the freely drained and the impeded drainage types of the drift are well defined, giving rise respectively to the Tryddyn and the Nerquis Series. Sedentary soils of this suite, forming the Bodkin Series, are confined to a small area on the upland lying between Caergwrle and Pont-y-bodkin.

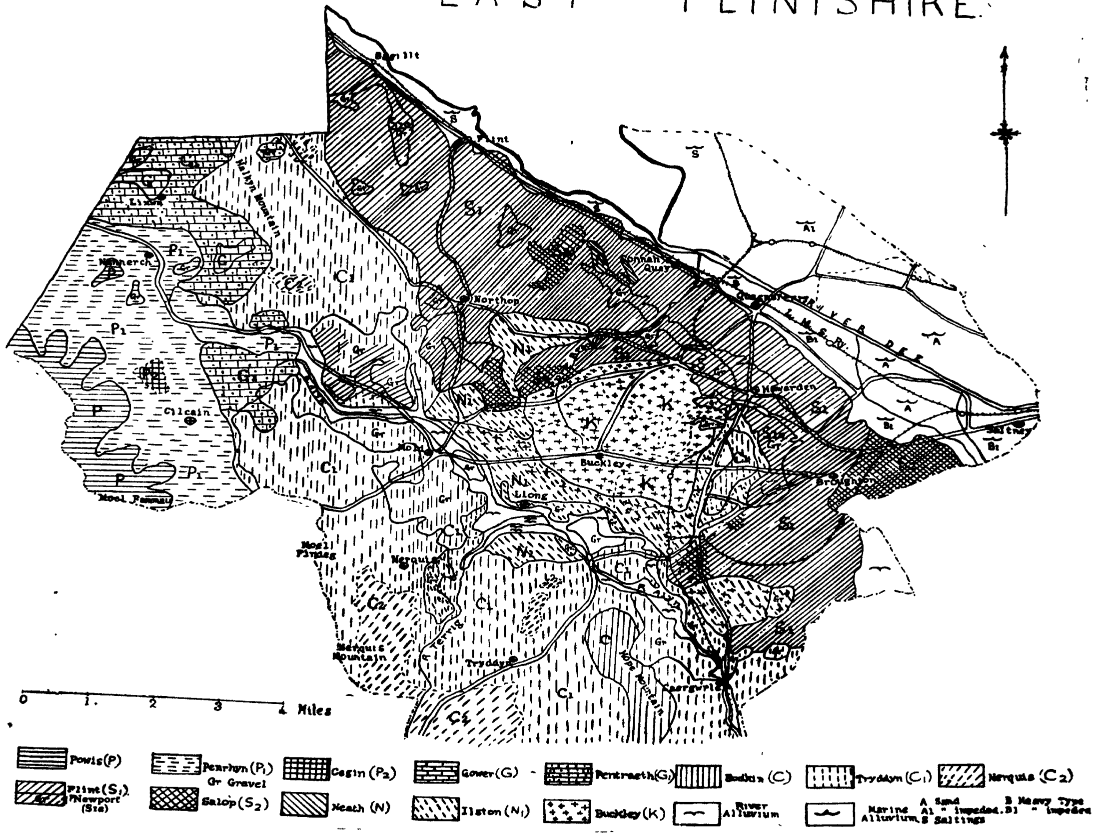
Occasional outcrops of Coal Measure sandstone occur, which give rise to soils of the Neath Suite, but their total area is small.

In the Buckley district, where Coal Measure rocks abound, the drift appears to be largely of local origin and gives rise to a soil series peculiar to this area.

The coastal country west of Halkyn and extending into the Cheshire Plain is underlain by boulder clay of Triassic origin, and the derived soils belong to the Salop Suite.

The drifts in the Alyn valley are mainly glacial sands and gravel of mixed Carboniferous origin. Between Rhydymwyn and Mold, there are prominent features of red Triassic sand which gives rise to soils of the Newport Series.

EAST FLINTSHIRE



The following types of soil have been recognised in the area

Parent material.	*Series.*	*Types.*
Millstone Grit.	Bodkin (C). Tryddyn (C_1). Nerquis (C_2).	Light loam. Light loam to medium loam. Medium to heavy loam.
Roughly-cleaved shales, grits, etc.	Powys (P). Penrhyn (P_1). Cegin (P_2).	Shaly light loam. Medium loam. Heavy loam.
Carboniferous Limestone.	Gower (G). Pentraeth (G_1).	Light loam. Gravelly or medium loam.
Coal Measure Sandstones.	Neath (N). Ilston (N_1).	Medium loam. Light loam. Fine sandy medium loam.
Triassic sands and Marles.	Flint (S_1). Salop (S_2). Newport (S_1a).	Heavy loam. Sandy medium loam. Heavy loam. Fine sandy or gravelly loam. Loamy sand.
Mixed Carboniferous and Triassic drift.	Buckley (K).	Medium to heavy loam.
Estuarine Alluvium.		Loamy sand, free drainage. Loamy sand, impeded drainage. Clay loam, impeded drainage. Medium loam, seasonably wet.
River Alluvium.		Heavy silt.

Bodkin Series.

The Bodkin Series, which consists of sedentary soils on Millstone Grit, does not occupy a large area, being confined to the upper reaches of Hope Mountain. The profile consists of about nine inches of brown, gritty light loam over rust brown or orange brown brashy subsoil (see table of analytical figures). The rock lies at a depth varying from 12 to 20 inches below the surface.

A natural consequence of the open texture and high elevation of these soils is that the drainage is very free and there is a marked tendency to impoverishment of the soil by leaching.

The parent material of this suite is of a highly siliceous character and has a low content of plant food elements. The

fertility of these soils is therefore closely dependent upon treatment, lime and phosphate being most frequently deficient.

Tryddyn Series.

The soils of this series are derived from Millstone Grit drift and have free drainage. They are, typically, dark brown or slightly greyish-brown medium loams, usually of good depth, over yellowish-brown subsoils. Texture, however, varies considerably according to the nature of the drift. Gravelly light loams and clay loams have been mapped.

These soils are of fairly high fertility and are largely under arable cultivation.

Nerquis Series.

On Millstone Grit drift with impeded drainage, we have the Nerquis Series. These soils occupy small areas within the more extensive Tryddyn area. They occur mainly in the neighbourhood of Nerquis mountain. The degree of impedance varies widely and types ranging from heath swamps to moderately wet grazings are seen. On the upper slopes of the mountain, dry compact peat lies on yellow clay, and carries almost pure stands of heather with occasional Vaccinium.

The better types of the cultivated area are mostly under grass. They produce a late growth and the herbage is characterised by rushes and sedges. Improvement of the drainage could easily be effected in many parts.

Powys Series.

The extent of the Powys Series in this area is confined to the upper reaches of the Moel Fammau Range. The profile consists of four to six inches of a dark brown shaly light loam containing high amounts of organic matter over yellowish-brown shale brash. The open texture, shallowness, and exposed situation of these soils results in a poor type of herbage which consists mainly of heather and Vaccinium.

Penrhyn Series.

Local drift of Wenlock Shale material covers the foot slopes and gives rise to the Penrhyn and Cegin Series.

With free drainage we have the Penrhyn Series. They are brown or slightly yellowish-brown in colour, whilst the texture and depth vary according to the amount and condition of the shale material present. A fairly typical profile consists of a silty

medium loam over yellow-brown heavy loam with fine shale distributed throughout.

These soils are of good fertility and are largely under arable cultivation. The analytical figures indicate a satisfactory lime and potash status, whilst phosphate appears to be deficient.

Cegin Series.

The Cegin Series, developed with impeded drainage, occupy a small area in the neighbourhood of Cilcain. The soils are generally greyish-brown or grey heavy silt loams over yellowish-grey impervious subsoils.

The degree of impedance varies considerably as reflected in the variety of herbage types. The worst types in this series are rushy wastes with occasional developments of peat. The better portions, which have been improved by cultivation, constitute cold land carrying moderately rushy pastures. Most of the area occupied by these soils has favourable slope and improvement by drainage would appear to be easily practicable. As regards the plant food status, the chief need is for phosphate.

Gower Series.

The major portion of the area which may be classified in the Gower Suite consists of rough mountain common, strewn with coarse limestone débris and carrying inferior herbage. The cultivated limestone soils occupy a minor area.

The soils of the Gower Series, formed in situ on limestone, occupy isolated patches on the crests of the higher limestone features. They represent the thin upland facies of this series. The profile, which varies considerably in depth, consists of brown light loam over reddish-brown subsoil and is stony throughout, rock generally occurring within fifteen inches of the surface. The drainage is free and lack of moisture is a common limiting factor of growth.

Pentraeth Series.

The Pentraeth Series, derived from limestone drift, occurs mainly on the western slopes of the Halkyn upland, a typical area lying in the neighbourhood of Lixwm. The drift varies considerably in depth owing to the hummocky nature of the underlying rock. Drainage is invariably free and there is often liability to drought on the upper features, where the profile is shallow. The soils are reddish-brown light or medium loams eight inches to a foot in depth overlying yellowish-brown medium loam. There is also a gravelly stony type formed on gravel features.

The lime status of the Carboniferous Limestone soils generally appears to be satisfactory. Whilst in many cases there is a high content of carbonate, complete removal of carbonate is exceptional. With regard to the phosphate status, it appears that treatment is uniformly effective in promoting improvement. With judicious treatment these soils are fairly productive and a fair amount of the area is under arable cultivation.

Neath Series.

The Neath Series formed in this area from Coal Measure sandstone occupies only a small area. The profile consists of about ten inches of slightly reddish-brown medium loam overlying yellowish-brown rubbly sandy loam. In character they resemble the soils of the Pennant Grit. The area is too small to generalise as to their fertility.

Ilston Series.

The Ilston Series consists of soils formed on Carboniferous sandstone drift with free drainage. They occur to a small extent in two localities, Northop and Llong. They closely resemble the sedentary soils in general character and from analytical data they appear to be in no urgent need of manurial treatment.

In the neighbourhood of Northop Hall there are small areas of Ilston soils derived from Coal Measure blue shales. These soils, owing to their very limited occurence, can only be mapped on a detailed scale. They are greyish-brown medium loams overlying yellowish-brown heavy loam subsoils.

Buckley Series.

A type peculiar to the Buckley district appears to be derived from mixed glacial drift composed mainly of non-calcareous Carboniferous detritus together with a varying proportion of Triassic material. The profile consists of about ten inches of greyish-brown heavy loam overlying yellowish-grey sandy clay. Drainage tends to be impeded throughout.

Triassic Soils.

Soils belonging to the Salop Suite, derived from Triassic drift, occupy an important area along the north and east of the county. Three main types have been recognised—the Flint, the Newport, and the Salop Series.

Flint Series.

The Flint Series consists of soils formed on heavy Triassic boulder clay with free drainage. The profile consists of reddish-brown medium to heavy loam overlying brighter reddish-brown clay loam or sandy clay. The subsoil is very commonly a stiff clay. Liming of these soils seems unnecessary. The figures for available phosphate are rather low, and good response is generally obtained by phosphatic treatment. These soils are generally of high fertility.

Newport Series.

The soils of this series, formed on glacial sands and gravels of Triassic origin, occur mainly in the Hawarden neighbourhood and on sharp features in the Alyn valley west of Mold.

They are deep reddish-brown sandy loams overlying bright reddish loamy sands. Drainage is free and often excessive and fertility is closely dependent upon treatment. A characteristic of these bright soils under cultivation is the low content of organic matter.

Salop Series.

The Salop Series consists of soils derived from heavy Triassic boulder clay and have impeded drainage. Areas of these soils occur in the Broughton district and near Kelsterton. A typical profile consists of about nine inches of greyish-brown heavy loam overlying red sandy clay. The soils in the Broughton district represent a very stiff phase of this series. There is marked impeded drainage and this area is entirely under grass. In the Kelsterton area, where the texture and drainage conditions are more favourable, a considerable proportion is under arable cultivation. Liming is generally unnecessary on these soils, but they show good response to phosphate treatment.

Estuarine Alluvium.

Estuarine soils occupy an area of about eighteen square miles, consisting mainly of reclaimed land, together with an area of saltings lying west of Queen's Ferry.

The reclaimed portion comprises four main types, namely:

(1) Dark brown loamy sand with free drainage but liable to seasonal floods. A considerable area of this type is under arable cultivation.

(2) Dark greyish-brown loamy sand with impeded drainage carrying inferior grazing.

(3) Grey clay silt with impeded drainage wholly under grass, which, in parts, is of fair quality.

(4) Greyish-brown medium loam subject to seasonal wetness. The soils of this type are mainly under grass of fair quality.

We have not sufficient experience of these soils to generalise as to their plant food status.

River Alluvium.

The only river alluvium of note in the area is that of the Alyn, extending from Rhydymwyn to Hope. Most of the alluvium is permanently wet and in parts liable to floods. The soil in general is a heavy silt modified in places by the development of peat.

We give in Table I (p. 205) analytical figures of some representative soils. We have not included figures for citric soluble potash and phosphate, because they vary so much from soil to soil that no individual figure can be taken to be representative of the series in the same way that the mechanical analyses can be taken. The mechanical analyses were carried out by the A.E.A. official method.

Vale of Clwyd District.

Topography of area surveyed.

The area surveyed comprises that part of the Vale of Clwyd north of Llanynys, together with the adjoining country bounded on the east by the Clwydian Hills, and extending into the Denbighshire uplands to include Foel Gasyth and Moel Fodiar.

Generally speaking, the area exhibits two distinct types of contour. The northern part of the area, lying between Abergele and Prestatyn and extending as a broad belt south-eastwards along the Clwyd, forms a fairly uniform lowland plain, bounded by the foothills of the Clwydian Range on the east, and by a limestone feature, extending from Abergele to Llanrhaiadr on the west. A large area of this low-lying country is formed from river deposits and, owing to absence of slope, considerable portions are characterised by impeded drainage. The glacial drift, forming the margins of the plain, is gently sloping or undulating.

Contrasting in outline is the hill country forming the south-western portion of the area. Here the physical features are dominated by well-defined ridges and narrow upland valleys. The highest land reaches an elevation of 1800 feet.

The drainage of this upland region is effected mainly by the Rivers Elwy and Ystrad, and tributaries.

Geology.

The rocks underlying the area belong to the Silurian, Carboniferous, and New Red Sandstone systems.

The Silurian rocks, here almost wholly represented by Wenlock Shales and fine-grained grits, form the hill country of the south-west. In this part, the conformation of the land surface closely reflects that of the country rock. This is particularly

TABLE I.

Mechanical analyses of typical Flintshire soils.

Series.	*Bodkin.*	*Tryddyn.*	*Penrhyn.*	*Cegin.*	*Flint.*	*Salop.*	*Newport.*	*Pen-traeth.*	*Buckley.*	*R. Alun Alluvium.*	*Estuarine Sand.*	*Estuarine Clay.*
Locality.	*Pont-y-bodkin.*	*Tryddyn.*	*Nannerch.*	*Cilcain.*	*Queen's Ferry.*	*Brough-ton.*	*Hawarden.*	*Lixwm.*	*Hope.*	*Pont-blyddyn.*	*Sealand.*	*Brough-ton.*
Coarse sand ...	21.5	18.6	16.6	5.4	20.5	3.8	43.7	19.5	16.8	5.4	0.4	2.0
Fine sand ...	43.9	36.8	16.3	17.8	28.7	15.8	31.4	29.2	37.9	20.9	81.6	18.6
Silt ...	11.8	18.9	32.9	40.7	13.5	19.3	6.3	19.3	16.5	28.5	2.7	19.0
Clay ...	11.5	12.8	19.5	22.3	25.4	48.4	9.9	14.3	17.0	27.1	4.0	38.1
Hygroscopic moisture ...	2.5	2.7	2.5	2.8	3.4	4.7	1.5	3.7	3.5	3.8	1.0	5.0
Loss on ignition	8.6	9.2	9.5	10.5	9.4	8.4	4.8	12.3	8.9	11.6	6.6	14.0

the case on the ridges where the soil profile shows fairly constant transition from soil to parent rock. Drift material of local origin occurs extensively in the valleys and the soils of the region belong, as a whole, to the Powys Suite.

Carboniferous Limestone forms features near Denbigh,

Henllan, Llanrhaiadr, and at Cefn Meiriadog. Only in the Denbigh area do we find limestone soils of satisfactory depth, though the extent of these is small. The limestone of Cefn Meiriadog is mainly evident as a rocky scarp; the derived soils are confined to a narrow margin on the upper southern slope. The main area of limestone soils occurs near Llanrhaiadr. Here the predominant type consists of shallow soil on rock.

A small exposure of New Red Sandstone is met with on the skirt of the Clwydian alluvium, near St. Asaph. Whilst this probably represents the parent material of some of the soils mapped in this area, it does not give rise to a soil series in situ, owing to the occurrence of drift. The sands in the Wheeler valley, as well as the sandy drift lying in the neighbourhood of Llandyrnog, appear to be derived from the local Bunter Sandstone.

The boulder clay which occupies most of the lowland is mainly of Triassic origin.

Soil Series.

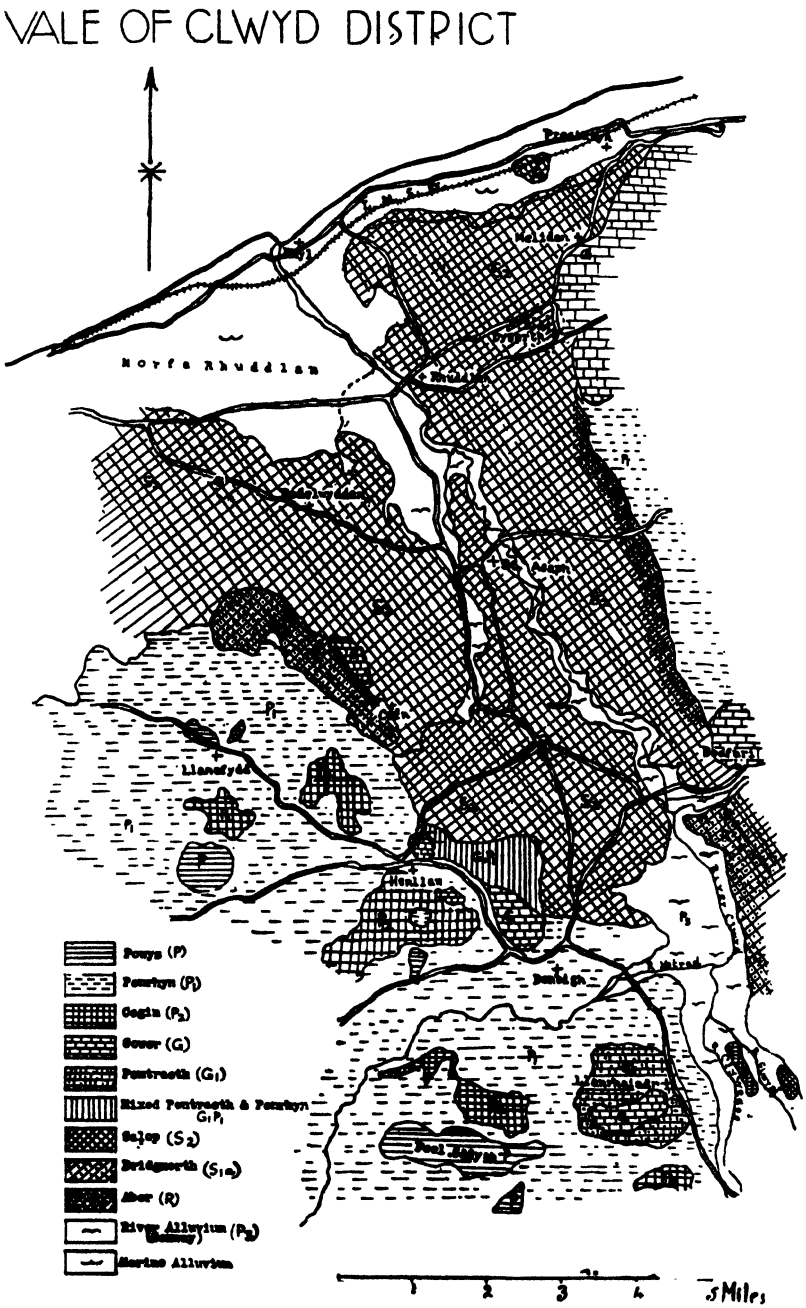
The following are the principal series and types encountered:

Parent material.	*Series.*	*Types.*
Palaeozoic shales, fine-grained sandstones, etc.	Powys (P). Penrhyn (P_1). Cegin (P_2). Conway (P_3).	Shaly medium. Gravelly to medium. Medium to heavy silt. Silty medium to clay silt.
Corboniferous Limestone.	Gower (G). Pentraeth (G_1).	Light to medium. Medium.
Triassic Marl and Sandstone.	Salop (S_2). Newport (S_1a).	Medium to heavy clay. Sandy light.
Shales and Trias.	Aber (Shale drift overlying Triassic drift).	
Marine Alluvium.		Clay silt.

In addition, there are soils derived from mixed drifts which may be best regarded as local series. The most extensive mixed type is that formed from limestone and shale, areas of which occur in the neighbourhood of Llanrhaiadr and in the country immediately north of Denbigh. Along the eastern margin, the Triassic drift has been largely modified by admixture of shale derived from the adjoining foothills.

The alluvial soils as a whole appear to be derived mainly from Palaeozoic shales and are classed in the Conway series.

Occasionally the profile in parts of the Clwyd alluvium shows



For Bridgnorth in the key to map above read Newport.

evidence of slight admixture of Triassic material. The deposits

forming Morfa Rhuddlan are probably of very mixed geological origin, though it would appear that shale material deposited by the River Clwyd has made extensive contribution.

The various soil series recognised may now be described :—

Powys Series (P).

The Powys series, which consists of sedentary soils on shales, does not occur very extensively owing to the prevalence of drift, and is confined to the upper reaches of the higher features, as for example, Moel Fodiar and Foel Gasyth. The profile is generally shallow, consisting of reddish-brown loam matrix with a high content of coarse shale which has the effect of maintaining very open texture. On the steeper slopes, the highly ferruginous appearance of the entire profile would seem to indicate a marked degree of surface erosion. Drainage is excessively free, and owing to the unfavourable location of these soils, they are mainly under bracken and gorse with occasional patches of fescue grazing.

Instances of recent reclamation of some of this land have been seen and it would seem that the returns hardly warrant the cultivation entailed for the eradication of the natural herbage and the manurial treatment necessary to remedy the soil deficiencies. Here, where portions have been so treated and put down to grass, it was evident that conditions were unfavourable, and deterioration to natural type, as indicated by high moss content, together with heath grasses and gorse, is proceeding apace.

Occasional areas of Powys soils occur on the lower cultivated ground. The drainage is usually very free and these soils generally show signs of impoverishment by leaching. This condition appears to be reflected in the prevalence of bent grass in the pastures. In some parts almost pure stands of this grass have been observed, affording very inferior grazing. Where such conditions obtain, the lime and phosphate status is very low, and improvement must be based on manurial treatment.

Penrhyn Series (P_1).

The Penrhyn soils, derived from shale drift with free drainage, are more widely occurring. They vary in texture from gravelly light loams on glacial gravels and deltaic deposits to medium or heavy loams on the more compact boulder clay. There is generally a high content of coarse shale material.

From the analytical data of a number of samples of this series, it appears that the available phosphoric acid is consistently

low. As regards lime and potash, the conditions seem to be satisfactory. Liming of these soils as a general practice has been discontinued, and the satisfactory status must be attributed to the liberal treatment given in former years. It was observed in the Llanefydd district, where a high proportion of the land is under arable cultivation, that these soils are capable of producing heavy yields of oats even at elevations reaching 900 feet. Here, however, on the more gravelly types, the growth is closely dependent upon the rainfall.

Cegin Series (P_2).

The shale-derived soils with impeded drainage, constituting the Cegin series, cover large portions of the Denbighshire uplands. They are generally intermingled with the Penrhyn series and their distribution is patchy and irregular. The degree of impedance varies widely and all gradations occur from improved types tending to resemble the heavier Penrhyn soils, to the wet uncultivated portions largely covered with rushes and sedges. Numerous isolated instances of drainage improvement have been observed but these can only be recorded on a large scale map.

A typical profile, closely resembling that seen in other parts of the country, consists of dark greyish-brown silty medium loam over dull yellowish-brown heavy loam. Rusty mottlings indicating drainage impedance occur throughout. The drier types may be regarded as moderately good land and considerable portions are under arable rotation.

The most inferior types occur in the Llanefydd parish. Here, with slight slope, the conditions have favoured the development of dark amorphous peat, while rushes and sedges, with occasional heather and nardus, form the bulk of the herbage. The profile consists of a fairly uniform heavy silt loam, markedly peaty in the top six inches. In its present condition, this land is very largely waste, whilst great improvement seems possible by a simple system of drainage.

As regards the plant food status of the Cegin soils, the most common deficiency is seen in the figures for phosphoric acid. The greatest need is for improvement of the moisture conditions.

Conway Series (P_3).

The Conway series, formed on river deposits derived from shales, is represented by the alluvium of the Clwyd and the Clywedog. The soils associated with the River Elwy also belong to this series. The Clwyd alluvium, with which may be considered the coastal flat lying between Abergele and Prestatyn,

forms a featureless stretch extending inland for several miles. Having regard to the exceedingly small gradient, an average of about six feet per mile, and to the fact that the River Clwyd is tidal beyond Rhuddlan, it is not surprising that most of the land is badly affected by a permanently high water table. Whilst there are very few portions with satisfactory drainage, large tracts are permanently wet rushy wastes.

The soil profile is fairly uniform in character, consisting of brownish-grey heavy silt loam over yellowish-grey and slightly stiffer subsoil. The clay and silt fractions amount to approximately 70 per cent. of the total soil. Occasionally, slightly pebbly subsoils occur, but they have no apparent influence on the soil. Though the major portion is characterised by poor drainage and is unsuitable for cultivation, there are broad areas, as for example, near Brook House, which are of reputed high quality. The soil is silty and compact, with indications of slight impedance, but with good management they are highly productive. A stretch of alluvium lying immediately south of St. Asaph, appears to be fairly satisfactorily drained and the pastures are noted for their high feeding value.

The Elwy alluvium gives rise to soils of more open texture containing appreciable amounts of coarse shale material. There is generally definite slope, and, owing to the fact that the river level is considerably below that of the adjoining land, drainage is fairly satisfactory. The deposits between Pontyralltgoch and St. Asaph consists mainly of river-terrace gravels which give rise to good deep meadow soils with free drainage. North of St. Asaph, the Elwy alluvium widens extensively to form a featureless flat which merges into the main Clwyd area. The profile consists of mottled stoneless clay silt. A typical sample contains 75 per cent. of fine fractions, mainly silt. Although the soil has the mottled grey appearance characteristic of poor drainage, it appears that the conditions are such as to favour the establishment of high quality fattening pastures for which this locality is noted.

The analyses of a number of samples of the Conway Series tend to indicate a deficiency of available phosphate. The content of lime and potash appears to be adequate.

Gower Series (G).

Owing to the occurrence of glacial drift, the areas occupied by soils derived from Carboniferous Limestone are more limited than the extent of the solid formation would suggest. In this

area, as in other parts, we have found that the soil formed from limestone may be classified into two main types, a thin upland facies and a more fertile deeper lowland facies. There are also small areas where these soils are pockety.

The upland facies, seen in the Llanrhaiadr district, and, to a very small extent at Henllan, is the more widely occurring. The profile seldom exceeds eighteen inches in depth and the rock is often within twelve inches of the surface. The soil is reddish-brown, open in texture, and in the shallower phases, often highly calcareous owing to a high content of disintegrated rock. Drainage is invariably free and liability to drought is a common condition.

The lowland facies occupies only a small total area, the best development of this type occurring on the lower slopes of the limestone ridge lying between Denbigh and Henllan. The profile is deep and the soil apparently of good fertility.

Salop Series (S_2).

The Salop series, consisting of soils formed on heavy Triassic boulder clay with impeded drainage, occupies an extensive area in the Vale. A fairly typical profile consists of about eight inches of dull-brown heavy loam over brown clay loam, with reddish clay below eighteen inches. The entire profile is practically stoneless. Variations appear to be due largely to the mode of occurrence of the clay subsoil. Where the clay lies deep in the profile, this condition is usually indicated by better drainage and more open texture of the surface soil. Conversely, where the clay lies near the surface, the texture is correspondingly heavy and the drainage very defective. Where the latter condition obtains, it would seem that the amount of drainage by percolation is very small. The defective moisture conditions in most of this type are indicated in the herbage, rushes being a common feature. The heaviest phase of this series is exemplified in the neighbourhood of Trefnant, where stiff clay lies within a few inches of the surface.

As regards improvement of the drainage, there are certain areas which, mainly owing to the absence of slope, offer small possibilities, but there are other areas where conditions are more favourable. Whilst spade drains are desirable, the adoption of mole draining might well be recommended. As regards the existing drains, there is little doubt that many of them lie too deep to serve their purpose.

A significant feature of the area occupied by these clay soils is the distribution of marl pits, which are probably a relic of the days when this land was devoted to corn growing. The heavy dressings of lime, applied with local burnt clay as marl, in addition to satisfying the needs of the crop, served the most important purpose of facilitating the cultivation of deep furrows. The total area of these soils now under the plough is very small, being confined to the more friable portions. Of the arable crops raised, beans, once widely grown in this district, still feature in the economy of winter keep.

Liming of these soils seems unnecessary. The figure for available phosphate are rather low and a good response is generally obtained by phosphatic treatment, particularly from basic slag.

Newport Series (S_1a).

Contrasting with the stiff clay loams of the Salop series, we have the sandy loams of the Newport series, occurring in this area in the neighbourhood of Llandyrnog and also near Dyserth. They are bright reddish sandy loams of ample depth, extremely free working and well suited to intensive cropping. On the upper parts of the sandy features there is liability to seasonal drought. Owing to their very free drainage, they are likely to require complete manurial treatment from time to time, particularly with regard to lime.

Aber Series.

A minor area lying in the Elwy valley adjoining Cefn Meiriadog has a profile consisting of a varying depth of shale drift over Triassic clay, being similar to the Aber series met with in north Caernarvonshire. The clay often lies near the surface and has a marked ill effect on the drainage. As a type, these soils closely resemble in character the heavier Cegin Series.

Marine Alluvium.

About ten square miles of the area is formed of a deposit of estuarine mud. It is a monotonous treeless flat characterised by impeded drainage and used as rough grazing. Although the soils of this portion have not been mapped in detail, we have sufficient data to indicate that the profile is fairly uniform throughout. It consists of brownish-grey heavy silt loam overlying bluish-grey clay silt.

The status of these soils with regard to plant food does not appear to be unfavourable, the main need being for physical improvement by drainage. The possibilities in this respect are,

TABLE II.

Mechanical analyses of typical Vale of Clwyd soils.

Series.	*Powys.*	*Penrhyn.*	*Cegin.*	*Gower.*	*Conway (R. Elwy).*	*Conway (R. Clywedog).*	*Conway (R. Clwyd).*	*Salop.*	*Newport.*	*Estuarine Mud.*
Locality.	*Moel Rodiar.*	*Llan-elydd.*	*Henllan.*	*Henllan.*	*St. Asaph.*	*Llanynys.*	*Rhuddlan.*	*Denbigh.*	*Bodfari.*	*Morfa Rhuddlan.*
Coarse sand ...	11.7	17.0	7.6	10.4	8.8	1.4	1.0	7.9	33.7	2.7
Fine sand ...	14.0	20.6	25.6	26.9	14.4	8.5	18.8	17.7	40.9	15.2
Silt ...	30.7	26.0	30.3	24.0	46.5	50.7	47.0	32.9	10.3	33.1
Clay ...	24.8	23.0	24.6	21.0	20.5	23.0	20.3	27.0	9.0	32.5
Hygroscopic moisture ...	4.0	2.6	2.6	3.2	2.5	2.8	2.1	3.5	1.0	3.7
Loss on ignition	15.2	9.9	8.9	11.2	10.1	10.3	9.6	10.2	4.9	12.1

however, very limited, owing to the almost complete absence of slope.

In Table II are given some typical analyses of the series encountered in this area.

SOME ASPECTS OF THE GRADED MILK MOVEMENT IN WALES.

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The movement for the grading of milk in Wales dates effectively from the application of the Milk (Special Designations) Order in 1928. The subject of clean milk production speedily engaged the attention of Public Health and Agricultural Education Authorities throughout the Principality. The results of routine bacteriological examination of Graded Milk samples at the five laboratories performing this work has appeared to the authors of this article worth collecting and analysing.

Public Health aspect.

There are two main hygienic reasons for encouraging the production of clean milk :—

1. To avoid transmission of infective diseases.
2. To ensure that the milk retains its best quality as a food.

The grading of milk is designed to ensure that the number of bacteria sent out in the marketed product is kept at the lowest possible level. To reach this standard, thorough hygienic methods have to be followed during production and distribution. These methods do not provide any sure safeguard against the presence of disease producing bacteria in the milk, but they go a considerable way towards minimising the danger by concentrating attention on the need for stringent methods of cleanliness and sterility.

If a cow's udder is infected with disease producing bacteria, these will inevitably gain access to the milk however careful the technique. If a dairyworker harbours disease germs, the clean milking technique minimises considerably the chances of these reaching the milk, and if they do reach it, their rate of increase is slowed if the cooling process is properly carried out. The efficient clean milk producer therefore should, in addition to following the approved technique, bear in mind that disease in

the cow or in any person handling the milk, is a source of danger to public health and may render useless the efforts made to produce clean milk.

The excessive activities of bacteria in milk, apart from the obvious effect of " B.coli " in tainting and souring the milk, tend to diminish the food value. For this reason, if for no other, grading is to be encouraged as safeguarding the food value of milk.

The vexed problem of tubercle infection is not fully covered by the grading of milks, but unquestionably the problem is partially met by the method of tuberculin testing and the fuller veterinary inspection of cows arising out of this. Clean milk methods afford no safeguard against the danger of the tuberculous cow, but their combination with tuberculin testing and veterinary inspection, as with Certified and Grade A (T.T.) milks, does at least assist in minimising to an important extent the sale of milk infected with tubercle.

It is not our purpose in this article to enter into the pros and cons of pasteurization as a safeguard against milk borne diseases, but there should be common agreement that, on hygienic grounds at any rate, all milk should be produced by hygienic methods, whether or not it is subsequently to be pasteurized.

In addition to the routine official testing of Graded Milk, the periodical bacteriological examination of ordinary market milk is a valuable method of controlling the hygienic quality of the general supply.

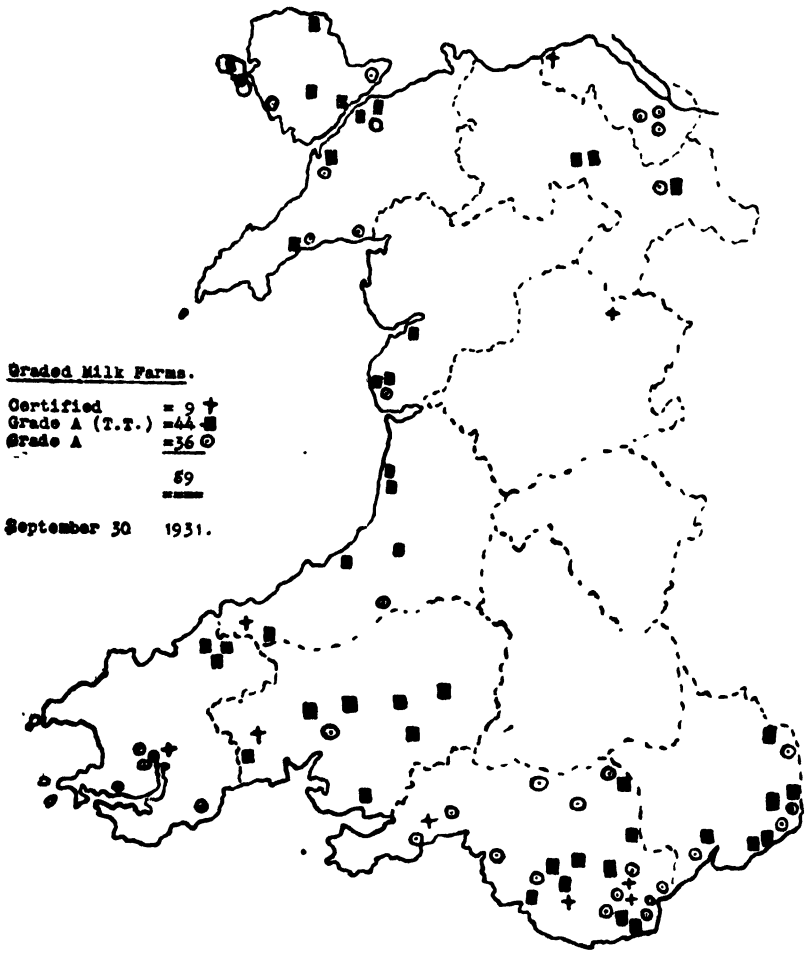
The results of the examination of random samples of ungraded milk, tabulated in this paper, show a great improvement in hygienic quality since 1923; in effect the general milk supply tends to approach the bacteriological standards required for Grade A. This undoubtedly is to be ascribed to the educative effect of the grading movement and to the realisation by farmers and retailers that the clean milk technique is practicable and worth while for itself. There appears good reason to believe that the Grade A (T.T.) standard could very well become the universal standard, with general advantage to the public health.

Distribution of Producing Farms.

The distribution of Certified, Grade A (T.T.) and Grade A herds is shown in Figure 1. The majority of the " licenced " herds are situated within easy reach of the various industrial areas or on the outskirts of the summer resorts. There is a fair demand for Graded Milk in the larger towns of Glamorgan and

Monmouth, and it is supplied by herds located near the population centres, supplemented by supplies from Carmarthen, Pembroke, and South Cardigan. Two smaller localised areas of licenced herds are found in the Flint-Denbigh industrial area, and along the Menai Straits. The other Graded herds are situated in close proximity to the various summer resorts of the Cambrian Coast. Practically all the milk sold off the " Graded " farms is consumed within the Principality, only three producers selling any over the border.

FIG. 1.
Producers of Graded Milk (Wales).



The number of licences granted in the various countries is given in Table I. Taking the number of cows and heifers in milk and in calf into consideration, Wales is well ahead of England in

the proportional number of herds producing Grade A (T.T.) milk. On the other hand the number of ordinary Grade A herds is proportionally low.

Volume of Graded Milk produced annually.

The total number of cows and heifers in milk and in calf in Wales during 1930 has been estimated at 337,000. Allowing a rather low average yield per cow of 344 gallons[1] per year (1) the total yearly production is approximately 116 million gallons. The proportion of liquid milk sold off the Welsh farms is estimated to be as low as 49 per cent., large amounts being sold in the form of butter, or consumed on the stock rearing farms.

TABLE I.

Graded Milk Producers, 1930-1.

Country.	*Cows and* heifers in milk and in calf in 1930.*	*Relative proportion of cows and heifers.*	*Certified producers.*	*Grade A (T.T.).*
England	2,378,000	1	178	201
Wales	337,000	1/7th	9	44
Scotland	453,000	1/5th	64	76
Northern Ireland	256,000	1/9th	—	45

* *Journal of Dairy Research*, Vol. III, page 180.

Country.	*Grade A.*	*Total graded producers.*	*Particulars obtained for*
England	608	987	30/9/31
Wales	36	89	30/9/31
Scotland	24	164	1930
Northern Ireland	—	45	1931

From data supplied by the Welsh Board of Health it was found that there were 1,357 milking cows on the fifty-three farms producing Certified and Grade A (T.T.) milk during 1931; an average of 25.6 per herd. The average number of milking

[1] Excluding whole milk fed to calves and pigs.

cows in the Grade A herds can safely be estimated at the same figure, thus giving a total of approximately 2,800 in the eighty-nine graded herds.

It is obvious that the annual milk yield per cow in the case of the licenced herds can be placed very much higher than the low yield of 844 gallons referred to above. The latter covers all the stock rearing and general purpose herds of the non-dairy districts. The average yield of most of the herds recorded by the various Milk Recording Societies in Wales is above 550 gallons, a large number being even over 700 gallons. It was found during an investigation in 1925 that the average annual milk yield per cow of twenty-four Grade A (T.T.) herds in Berkshire was 618 gallons (2). An estimated yield of 600 gallons for the cows in the licenced herds would therefore not be in any way excessive. The approximate amounts of graded milk produced and sold, as well as the relative proportion to general market milk, are shown in Table II. The production of Graded Milk is a specialised form of dairy farming, and it is estimated that 90 per

TABLE II.

	No. of cows and heifers in milk and in calf 1930.	*Gallons milk produced annually.*	*Gallons sold off farms annually as liquid milk.*	*Per cent. of total milk sold.*
All herds in Wales ...	337,000	116,000,000	57,000,000	—
Licensed herds (Certified Grade A (T.T.) & Grade A)	2,300	1,380,000	1,242,000	2.2
Tuberculin Tested licensed herds (Certified and Grade A (T.T.))	1,357	814,000	733,000	1.3

cent. of this commodity is sold off the farms as liquid milk. Taking these factors into consideration, the volume of graded milk sold forms over 2 per cent. of the total liquid milk marketed, whilst Tuberculin Tested milk is over 1 per cent. The proportion of graded milk consumed in Wales is actually higher than these figures show, since no allowance has been made for the large supplies of ungraded milk sent to London, Lancashire and the Midlands.

Bacteriological examination.

Samples of milk are taken for the Welsh Board of Health at monthly intervals from all Certified and Grade A (T.T.) herds, whilst the Local Public Health Authorities take samples from the Grade A farms at quarterly intervals. The five laboratories are so centrally situated that all samples can reach them well within twenty-four hours of milking. The use of ice-boxes for transport is not therefore insisted upon, but producers situated at a distance are informed that their use is recommended. Although there is inevitably a slight variation in the age of the samples on examination, this rarely exceeds twenty-four hours and generally ranges from 6-18 hours.

The samples are submitted to a strictly standardised scheme of bacteriological examination. The bacterial count is obtained by incubating 1/10, 1/100 and 1/1000 c.c. dilutions of milk in nutrient agar plates for two days at 37°C. The presence or absence of Coliform organisms (" B.Coli ") is detected by inoculating appropriate milk dilutions into bile salt litmus lactose peptone broth, incubating for three days at 37°C. and noting the production of acid and gas in the tubes. The bacteriological standards for the three designated grades in England and Wales are as follows :—

Grade.	*Bacterial count as expressed by number of colonies on nutrient agar plates.*	*" B. coli " content.*
Certified ...	Not to exceed 30,000 per c.cm.	Not to be present in 1/10 c.c.
Grade A (T.T.) and Grade A ...	Not to exceed 200,000 per c.cm.	Not to be present in 1/100 c.c.

The results of the tests carried out at the five laboratories for the last seven years are given in Table III. It will be noticed that only a small percentage of the samples fail to attain the desired standards, and that there has been a steady improvement since 1925 in this respect. Only 14 per cent. of the Certified and 9 per cent. of the other grades were below the standards during 1931. Failure to reach the recognised standards tends to be greatest during June, July and August.

An analysis of the bacteriological results for the samples below the standards shows that in the case of the Grade A (T.T.)

TABLE III.

Summary of bacteriological examination of graded milk samples at Bangor, Cardiff, Newport, Swansea, and Aberystwyth, 1925-31.

Grades.	1925.			1926.			1927.		
	No. of samples.	*No. within standards.*	*Per cent. within standards.*	*No. of samples.*	*No. within standards.*	*Per cent. within standards.*	*No. of samples.*	*No. within standards.*	*Per cent. within standards.*
Certified ...	23	17	74	23	14	61	34	22	65
Grade A (T.T.) and Grade A	225	195	87	322	280	87	461	421	91
Totals ...	248	212	85	345	294	85	495	443	90

Grades.	1928.			1929.			1930.		
	No. of samples.	*No. within standards.*	*Per cent. within standards.*	*No. of samples.*	*No. within standards.*	*Per cent. within standards.*	*No. of samples.*	*No. within standards.*	*Per cent. within standards.*
Certified ...	45	38	84	68	54	79	88	78	89
Grade A (T.T.) and Grade A	595	534	90	722	625	87	805	711	88
Totals ...	640	572	89	790	679	86	893	789	88

Grades.	1931.			*Totals.*		
	No. of samples.	*No. within standards.*	*Per cent. within standards.*	*No. of samples.*	*No. within standards.*	*Per cent. within standards.*
Certified ...	99	85	86	380	308	81
Grade A (T.T.) and Grade A	1133	1032	91	4263	3798	89
Totals ...	1232	1117	91	4643	4106	88

Percentages to nearest unit.

and Grade A group a large percentage (59 per cent.) of the failures are due to excessive " B.Coli " content (Table IV). The Certified " failures " on the other hand are fairly equally distributed between the two tests.

TABLE IV.

Analysis of failures to attain bacteriological standards (Aberystwyth, Cardiff, Bangor, and Newport), 1925-31.

Grade.	*No. of samples.*	*No. below desired standards.*	*Samples below standards on both bacterial count and coliform organisms content.*		*Samples below standards on bacterial count alone.*		*Samples below standards on "B. coli" content alone.*	
			No.	*Per cent.*	*No.*	*Per cent.*	*No.*	*Per cent.*
Certified Grade A (T.T.)	140	18	8	45	6	33		22
and Grade A	1,497	166	42	25	26	16	98	59

Influence of the Graded Milk movement on the general Milk supply.

Although only eighty-nine farms are licenced to sell Graded milk, it is evident from the results obtained from the bacteriological examination of approximately 4,000 samples of ungraded milk annually that there has been a great improvement in the hygienic quality of the market milk supply in Wales, and that many dairy farmers are showing their ability to produce milk within Grade A bacteriological standards. The results given in Tables V and VI of the examination of random samples of ungraded milk at two laboratories form a very good illustration of this point.

TABLE V.

Beck Laboratory, Swansea.

	Official examination of graded milk samples.		*Bact. examination of ungraded market milk samples.*	
	No. of samples.	*Per cent. attaining desired Bact. standards.*	*No. of samples examined.*	*Per cent. of samples attaining Grade A Bact. standards.*
1924	58	79	343	40
1925	98	69	160	50
1926	185	70	202	37
1927	188	76	251	47
1928	141	82	177	52
1929	185	74	295	69
1930	209	82	168	77
1931	270	88	143	75

TABLE VI.

Cardiff and County Public Health Laboratory.

	Official examination of graded milk samples.		*Bact. examination of ungraded market milk samples.*	
	No. of samples.	*Per cent. attaining desired Bact. standards.*	*No. of samples.*	*Per cent. of samples attaining Grade A standards.*
1925	147	96	341	72
1926	194	97	324	64
1927	283	96	318	83
1928	369	94	445	81
1929	399	98	558	82
1930	481	92	671	78
1931	649	94	713	88

The success of the Clean Milk Movement is attributed to the characteristic keenness shown by Welsh people—producers, wholesalers, retailers, and consumers—in all matters pertaining to the dairy industry, combined with the educative effect of the Graded Milk Movement, Clean Milk Competitions, and Advisory County Dairy Work, stimulated by the enthusiasm of the Local Public Health Authorities and Medical Officers.

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THE IMPROVEMENT OF BUTTER—USE OF "STARTER".

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Complaints are sometimes heard as to the inferior quality of Welsh butter. There is, no doubt, some ground for this, but it is not the case that all Welsh butter is of poor quality. That there is room for improvement, however, is readily admitted. With this object in view, butter competitions have been carried out in Anglesey for three years, and for the last two years a "starter" scheme has been introduced to run, not exactly in conjunction with the competition, but more or less parallel with it. The present article deals with the results obtained through these two channels.

From the dairying point of view, Anglesey is primarily a butter producing county, scarcely any cheese being made. Milk-selling is on the increase, but butter-making on the farm predominates over the county generally, and this condition is likely to persist, for the following reasons :—

1. Anglesey is a well-known cattle rearing county and butter-making fits in better with this class of farming than either cheese-making or milk selling.
2. About 82 per cent. of the holdings are under 50 acres, and without some general system of co-operation each small farmer is likely to remain a butter producer.
3. There is a considerable local demand for butter as well as in the nearby quarrying districts of Caernarvonshire.

It is of the utmost importance for the farmer to produce butter of good quality. The art of producing butter of marketable quality is not confined to churning and the actual working of the butter. Attention must be paid to the dairy, utensils, cow-house, milking, straining, separating and, in particular, the management and control of milk or cream during ripening. The butter competition scheme covered all these phases of dairy work and in order to compare the relative efficiency of competitors a carefully considered scale of marks was adopted.

The first competition revealed two very striking results, namely, the relatively high standard of the butter from all the competitors when judged three or four days after production, and the poor quality of the same butter when judged about fourteen days old. In other words, the keeping quality of the butter was poor. From each competitor four samples of unsalted

butter were taken at different periods. Table I gives the average marks gained by each competitor, the last column showing the length of time after churning, during which the butter kept good and free from all taints.

TABLE I.

Competitor's number.	Marks gained as judged when three days old.					Keeping quality in days.
	Flavour 50.	Texture 25.	Moisture 15.	Colour 10.	Total 100.	
1	47	22	15	7	91	14 days.
2	46	21	15	8	90	11 ,,
3	45	21½	15	8	89½	12 ,,
4	44	22	15	8	89	8 ,,
5	44	22	15	8½	89½	11 ,,
6	44½	21	15	8	88½	7 ,,
7	44	22	15	8	89	7½ ,,
8	43	22	15	7	87	4½ ,,

To gain full marks for keeping quality, butter had to keep for twenty-one days, at a uniform temperature of 60°F., without developing any taints. This is considered a severe test for butter which has had no salt added to it to act as a preservative.

There is every reason to believe that farmers generally pay particular attention to cleanliness in the dairy and cowhouse. Churning and butter-making are for the most part carried out according to the latest methods. All the competitors had at one time or another been pupils at a dairy school, and it can therefore be assumed that greater attention was given to details than is usually the case in ordinary farm practice.

The butter the farmer consumes is his own product. He keeps for his family just enough from one churning to the next, say from three to five days. The butter when he consumes it at his own table is good and he sells it so in all good faith, but the general public may be consuming his product a fortnight later. In the meantime it has often developed taints, and the consumer condemns the butter and the farmer for producing what would appear to be such a poor quality article.

Starter Scheme.

The usual practice on the farm is to allow the cream used in buttermaking to ripen naturally, but even when using the same temperatures the results obtained by doing so are uncertain. At

times an approved flavour is obtained by spontaneous souring, whilst at others the taste is disagreeable.

The use of natural starters existed long before bacteriology became a recognised science, and it was not until 1890 that the main course of the reaction was demonstrated almost simultaneously, but quite independently, by Conn, U.S.A. (1), Storch, Denmark (2), and Weigmann in Germany (3). Following the work begun by these investigators the pasteurisation of cream and the use of starter became the general practice in most butter producing countries, particularly in the case of factory-made butter.

One of the chief functions of a good starter is to impart a desirable flavour and aroma to the cream and butter. Another very important property is that by the immediate increase of acidity in the cream the growth of undesirable bacteria is inhibited, thus giving a certain measure of control when ripening the cream.

In order to determine to what extent the addition of starter to unpasteurised cream would increase the keeping quality of butter made under ordinary farm conditions, the Anglesey Agricultural Education Committee put forward a scheme for carrying out tests on three selected farms within their area.

The ordinary practice of churning twice a week in winter and three times a week in summer was followed. The cream produced each day was equally divided into two separate vessels, one being ripened naturally and the other by the addition of quarter of a pint of starter to the first portion collected, the cream from subsequent milkings being added and thoroughly mixed with the bulk. When a sufficient quantity had been gathered it was allowed to stand for twenty-four hours before churning took place.

The two sets of cream, after ripening, were churned separately, and a small quantity of butter from each portion taken to test the keeping quality. The scheme was run for a period of nine months in 1930, and for a similar period in 1931. The starter was prepared and supplied by the School of Agriculture, University College, Bangor, weekly and in this way it was possible to maintain the starter at a known acidity and guaranteed purity. Table II gives the result of the starter as against the non-starter butter from each centre. To reduce figures to a minimum the average keeping quality of all the samples of butter taken from each centre for the period of two years is given.

On comparing the keeping quality of the two lots of butter from each farm there does not seem to be a pronounced difference. There is, however, a definite improvement in favour of

TABLE II.

	No. of samples.	Centres.		
		A.	*B.*	*C.*
Average keeping quality of butter from non-starter ripened cream	30	12 days.	18 days.	12½ days.
Average keeping quality of butter from starter ripened cream ...	30	14 days.	15 days.	14½ days.
Average improvement with use of starter ...		2 days.	2 days.	2 days.

the starter, the keeping quality being lengthened by two days. It is remarkable that the average improvement at each centre should be exactly the same, but as the period of trial extends over two years. some reliance may be placed on these figures.

The lengthening of the keeping quality period by only two days appears to be disappointing. The promoters of the scheme at any rate, anticipated a greater margin of difference, and the question arises whether the effect of the starter is really to be judged by the two days' extension. Ordinary farm conditions made it impossible to measure exactly the influence of the starter on the keeping quality. The continuous use of starter appears to have a beneficial effect on the bacterial flora of the dairy and particularly of the utensils. The starter and the non-starter cream were ripened in the same dairy and, therefore, the non-starter cream probably derived considerable benefit, indirectly, though no starter was added to the cream. In support of the contention that the non-starter cream derived benefit, it may be observed that one of the butter-makers under the starter scheme happened to be a competitor in a County Butter Competition in the previous year. A complete record of the keeping quality of the butter from this farm is known for the year 1929, when no starter at all was used, and also for the years 1930, and 1931, when starter was regularly employed in the dairy. On comparing the keeping quality of the butter in these two periods a very striking result is obtained, as the following figures show :—

Average keeping quality of butter in 1929 = 7 days.
Average keeping quality of butter in 1930 and 1931 = 14½ days.

Leaving out of account any difference in climatic conditions

and apart from the use of starter, there is no reason at all to suppose that the butter from this particular farm would keep longer in 1930 and 1931 than it did in 1929. As far as this centre is concerned the effect of starter on improving the keeping quality of butter appears to be very pronounced. It has actually more than doubled the keeping quality period.

Further evidence can be obtained by comparing the keeping quality of butter produced by competitors in the County Butter Competitions with that of butter produced under the starter scheme. Butter competitions have been conducted for three years—1929, 1930, and 1931, and in each year a different set of persons competed. Competitors in 1929, and 1930 used no starter, but for 1931 the competitors had starter occasionally. Taking the average keeping quality of the butter produced by competitors on eighteen farms, from which seventy-two samples were taken in 1929 and 1930 and that of the butter produced under the starter scheme, we have the following comparison :—

Average keeping quality of butter in the competitions = 9 days.
Average keeping quality of butter under the Starter Scheme = 14½ days.

Again taking the 1931 competitors, when starter was occasionally used, and the 1929 and 1930 competitors when no starter was used, the keeping quality of the butter in 1931 was decidedly superior.

Average keeping quality of butter in 1931 = 12½ days.
Average keeping quality of butter in 1929 and 1930 = 9 days.

It appears obvious, therefore, that the use of a starter for the ripening of cream was responsible for a marked improvement in the quality of the butter produced, even under ordinary farm conditions, and in the absence of any control over the temperature of the dairy. That it will completely solve the problem of producing high grade butter is another question.

It must be remembered that all the butter samples tested, and so far dealt with, were unsalted, both under the starter scheme and in the competitions. It now seemed desirable to determine what effect the addition of salt would have on the keeping quality of the butter produced from starter-ripened cream. Trials were accordingly conducted in 1931 under the starter scheme with salted as well as unsalted butter, both produced from the same starter-ripened cream. The results are given in Table III.

The addition of salt (about ½ oz. to 1 lb. butter) doubled the keeping quality period of butter from starter-ripened cream,

The number of samples tested is insufficient to draw definite conclusions, but it is clear that salt used in moderation considerably improves the keeping quality of butter.

TABLE III.

	Butter samples tested.		*Average keeping quality in days.*	
	Starter ripened and salted.	*Starter ripened unsalted.*	*Starter ripened and salted.*	*Starter ripened unsalted.*
Centre A	5	5	27	14
Centre B	8	8	30	15½
Centre C	2	2	34	14
	Average of three centres		30¼	14½

Welsh butter, generally speaking, is consumed locally and, as a rule, within fourteen days of its production. Occasionally it is quite possible that the butter may not be entirely used up till the third week. It should, therefore, keep good and without developing any taint for twenty-one days.

The work carried out by the Anglesey Agricultural Education Committee has proved that high grade butter can be produced under ordinary conditions existing on farms. Agricultural education has done much already to improve butter production, but so far attention has been mainly confined to hygienic questions, and to churning and the working of the butter immediately afterwards. Improved methods in these connections have resulted in a considerable and much needed improvement in the standard of production. Since 1914, when the present scheme of agricultural education was first inaugurated in Anglesey and the County Council established an Agricultural Department, the methods of producing milk and butter have to a large extent been modified. In 1914 it was difficult to find half-a-dozen farms in the county possessing separators; to-day it would be equally difficult to come across half-a-dozen farms without a separator.

It may be stated that while, generally speaking, excellent butter is produced in Wales if judged immediately after churning, the keeping quality of the product often leaves much to be desired. Much improvement can be effected, even if complete success cannot be secured, by introducing the use of a starter into the method of manufacture, thereby obtaining some measure of control over the ripening of the cream. The work of enlightening the farmer rests with the Agricultural Education Authorities, who

having done all they can in this direction might assist further by making arrangements for starter to be easily available for the butter producer.

The writer gratefully acknowledges the work of Miss P. M. Hickson, Dairy Bacteriologist, University College, Bangor, and Miss Jennie Jones, County Dairy Instructress for Anglesey, who were responsible for carrying out the starter scheme and for conducting the butter competitions.

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THE ERADICATION OF BRACKEN.

By MOSES GRIFFITH, M.Sc., WILLIAM EVANS, B.Sc., and E. E. WILLIAMS, B.Sc.,

County Agricultural Offices, Dolgelley.

For various reasons bracken may be said to be one of the worst weeds found on many farms in this country. On a mountain sheep farm it is a very serious pest, and in many cases appears to be increasing every year. Bracken occupies the best hill-land, as it requires a good depth of soil and a well-drained sub-soil; such land on a mountain sheep farm has a special value for the wintering of sheep. Yet its grazing value is considerably reduced by this weed, and the stock carrying capacity of the land greatly diminished.

Having realised the great loss caused by bracken in the county of Merioneth, it was decided to carry out some experiments in order to try and discover some cheap and satisfactory way to destroy it, for none of the old methods seemed adequate to destroy this perennial weed that is fast gaining ground.

A number of experiments on the destruction of bracken have been carried out at the College Farm, University College of North Wales, Bangor.

The method recommended was to cut the bracken two or three times during the season for about three years, or else to

cut once, about the middle of July (St. Swithin's Day), for five years. The great drawbacks to this method were the length of time necessary for the appreciable reduction of the pest and the cost of labour.

A large number of experiments have, from time to time, been carried out in order to try and find some more satisfactory means of combating this troublesome plant. Unfortunately, up to the present no really economic way of eradicating bracken completely has been found. In many localities large tracts of good ffridd-land[1] still remain idle and practically worthless, and are an eyesore to many sheep farmers and others.

The grass under bracken does not make anything like the growth that it does when in the open, and the quality of the herbage is very inferior. Even if the bracken is cut in the autumn the herbage is of very little value, as it is of too soft a nature and too weak to stand any adverse weather conditions, with the result that very little keep is obtained on bracken infested land.

In experiments conducted in America a good deal of success was obtained in controlling various weeds by the application on the land of various substances, chiefly sodium chlorate. The American method was to dress the land with sodium chlorate crystals.

During the year 1929 several experiments were carried out by the writers to test this method, viz., the application of sodium and potassium chlorate in powder form to destroy bracken. The chemicals completely destroyed the herbage for about twelve months, but grasses crept in during the following spring and summer. It was found that sodium chlorate had a more toxic effect.

During the summers of 1930 and 1931 it was decided to try the effect on bracken of solutions of various substances sprayed on the bracken when it had attained almost full growth. Solutions of various strengths of copper sulphate, potassium chlorate, sodium chlorate, and sodium carbonate were tried. But again it was found that a solution of sodium chlorate was the most effective.

Before any chemical was considered worthy of a trial for the purpose it was realised that it had to conform to the following requirements. First, it must be fairly cheap, so that the cost per acre for spraying would compare favourably with the older methods of eradication, such as cutting. Secondly, the chemical must dissolve readily in cold water so that it could be used with

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[1] Enclosed land between the hill farm and the open hill.

the nearest water supply available. Thirdly, it must be easily handled by farm hands without risk. Fourthly, the chemical, at whatever strength used, must be harmless to the live-stock, cattle or sheep, that may happen to be grazing on the area to be treated.

Sodium chlorate satisfied these requirements, being fairly cheap, readily soluble in cold water, quite harmless to those using it, and harmless to live-stock.

The results obtained from the preliminary trials carried out in 1930 justified the continuation of the trials, on a somewhat larger scale, during the following season. Therefore, during the summer of 1931 demonstration plots were laid down in about ten different centres in the county.

The preparation of the solution was very simple; the sodium chlorate was simply dissolved in cold water in a vessel, the only precaution necessary being to exclude any dirt that was likely to clog the sprayer. The solution was sprayed by means of a knapsack sprayer with a holding capacity of about three or four gallons. A sprayer holding four gallons is to be preferred because less time is wasted in re-filling.

Various strengths of the solution were tried, 2½ per cent., 2 per cent., 1½ per cent., 1¼ per cent., and 1 per cent.; even a 1 per cent. solution, viz., 8 lb. of sodium chlorate in 80 gallons of water, applied to one acre proved as effective as any of the stronger solutions.

In every case the bracken was withered and dead in a few days after the spray had been applied. The plots, with all the bracken killed, and hence appearing red among the green foliage of the untreated parts, were very conspicuous and attracted much attention. By the end of the summer there was some nice green grass growing on the plots that had been sprayed, while on the untreated area there was but very little grass, the ground being covered with the wilting foliage of the bracken. It will be very interesting next season to note the effect of the spraying.

The bracken was usually quite dry when the spray was applied, but in one or two cases the spray was applied after a fall of rain, and though the application was at the rate of about 8 lbs. of sodium chlorate in 80 gallons of water to the acre, it proved quite effective in killing the bracken. This suggests the possibility of applying a much weaker solution, provided it is applied when the plants are dry. This point will be further tested during 1932.

The price of the sodium chlorate is about 25*s.* per cwt., so the cost of spraying with a 1 per cent. solution at the rate of 80 gallons per acre would amount to about 1*s.* 9½*d.* an acre, exclusive of the cost of application. It was estimated that one man could spray about two acres a day with a knapsack sprayer, while two men with a horse sprayer could do 7 or 8 acres a day, much depending, of course, upon the distance of the water supply, and also on the contour of the land.

At two centres a horse drawn sprayer similar to that used for charlock spraying was employed and worked quite satisfactorily. Where the ground is fairly level, such a method of spraying can be adopted, and thus a large area can be covered in a comparatively short time.

Although it is rather too early to say definitely that this method of eradicating bracken has many advantages over the older methods in practice, the writers are of the opinion that it is, at any rate, a method of some promise. Once a cheap and effective chemical, which will not only destroy the leaves but also the underground portion of the plants, becomes available, the difficulty of finding an efficient and economical way of applying it will soon be surmounted.

It may, however, be remarked that one limiting factor, namely, the absence of any available water supply, may render this method very difficult or even impossible to carry out. In such a case the only alternative method, at present, is cutting.

Cutting.

A number of tests were also carried out on the effect of cutting both with scythes and machine, and their results confirmed the Bangor experiments.

Amongst the various machines used, mention must be made of the " Pugh Bracken Cutter ", a machine invented by a sheep farmer from Aberangell. It is of simple and unique construction, being on the roller principle with knives forming the tread, and in travelling, the cutting edge of the knife crushes and cuts the bracken stems at many points.

It is light in draught and capable of cutting from 8 to 10 acres a day. It has one advantage over all machines tested, that is, it can be used on very steep hill-sides, and it can safely be said that where a horse can walk, a " Pugh Bracken Cutter " will work.

THE CONTROL OF A WATERCRESS LEAF-BEETLE

(*PHAEDON COCHLEARIAE*).

By H. W. Thompson, M.Sc.,
University College, Cardiff.

A severe attack on Watercress (*Nasturtium officinale*) by the beetle *Phaedon cochleariae* was first brought to the writer's notice in July, 1930, by a large grower in West Glamorgan. On examination large beds of cress were found to have suffered such extensive foliage injury as to be quite unsaleable (1). At the time of the examination both the larval and adult stages of the beetle were present in enormous numbers, and apparently both were contributing to the injury complained of. Large numbers of eggs were also present on the under side of the leaves.

In addition to the leaf injury on the beds for cutting, the grower in question had other beds where the plants were allowed to flower and seed themselves down, the seedling plants being used to re-stock the larger beds later on. Numerous beetles were clustering on the flowering heads at the time, and pairing was taking place. The weather was bright and sunny, which accounts for the activity of the beetles; in dull weather the beetles hide, and very few are seen. These adult beetles were attacking the flowers and were so numerous that seeding was entirely prevented in 1930—the grower having to purchase new seed for seeding down purposes.

The grower reported that such extensive injury had never been experienced before, although some trouble had been met with for the previous five or six years. The loss at this centre was estimated at half a ton of cress rendered unsaleable by leaf injury, and the complete failure of seeding. In addition to this all the cress sold throughout the summer had to be looked over very carefully as the plants were washed, and all insects and damaged leaves removed, which added considerably to the amount of labour involved.

There are apparently two generations of this insect each year, and these generations overlap; at this centre it was observed that throughout the greater part of the summer the egg, larva, and adult stages were all present on the plants at the same time.

Most of the beds which should have been producing fresh cuttings of cress had been ruined at the time of examination, so

it was considered that at this particular centre it was too late in the season to attempt control measures that year—it was arranged, however, that a definite attempt to control the pest should be made in 1931, commencing early in the season as soon as the beetle appeared in numbers.

Control measures of various kinds have been used in different parts of the world. Chittenden (2) reports some measure of success following the use of Paris Green, mixed with flour and dusted over the plants when the dew was on. He reported that this measure was abandoned later owing to the substance forming a paste and sticking to the plant like glue. There are other marked disadvantages however, in using any arsenical substance for the control of this pest, as, although the plants are washed thoroughly before sale, there might be difficulty in ensuring that all traces of arsenic are removed.

At other places it has been found possible to flood the beds so that the plants are entirely covered, the insects are found to float up to the surface—then on releasing the water many of them are washed away down stream (3). At this particular centre this method was not possible, the beds being almost level with a large area of surrounding country and the flow of water through the beds being very sluggish. It remained, therefore, to try spraying or dusting with non-arsenical insecticides—sufficiently toxic to destroy the pest but which would not contaminate the cress in any way or affect its saleability.

Control measures tried.

The cress beds were examined in the last week of April, 1931. At this time the beetles were present again in enormous numbers, pairing was taking place, and egg laying had commenced; consequently spraying was commenced at once.

Three insecticides were selected for trial, namely :—

1. Pyrethrum wash.
2. A Derris-soap wash.
3. Derris powder.

These substances are known to be extremely toxic to insects, without possessing the disadvantages of arsenic, and it was considered that all traces of the sprays could be removed before sale of the plants.

The Pyrethrum wash was applied at approximately 1 per cent. strength. Both the sprays were applied by means of a knapsack sprayer with a lance extension. As the beds were not very wide it was possible to wet the surface of the foliage thoroughly from the banks.

The Derris was put on dry by means of a powder distributor with an extension which could be pushed down amongst the foliage, enabling a coating of the insecticide to be left all over the plants. The application of Derris in this way used rather a lot of powder, however, and owing to the cost of material this method was discontinued. The Derris Wash was used on the main beds and the Pyrethrum spray on the seeding plants and seed beds. This arrangement was made largely as a matter of convenience. Spraying was commenced at the beginning of May and repeated at intervals of about a week, as the weather permitted. Six or seven sprayings were given in all.

Estimation of the actual percentage of beetles killed was not possible owing to the dense foliage of the cress. It is probable, also, that many of the insects killed floated away on the water. There can be no doubt however, that spraying in this way was thoroughly effective as a control measure. By the middle of June beetles were comparatively scarce; the injury during 1931 was negligible, and seeding was normal, although in April the beetles were at least as numerous as in the preceding year. Both the Pyrethrum and the Derris wash were effective for the purpose used.

A further attack.

A further case of injury to Watercress by the Watercress Leaf-beetle was met with in 1931. A grower in South Monmouthshire reported that a bed 200 yards long had been rendered unsaleable during April and May, and the beetle *Phaedon cochleariae* was found to be responsible. A visit was paid to this centre on July 23rd, both beetles and larvae were very numerous and it was considered to be worth while attempting control measures.

At this centre it was possible to flood the beds. It was noticed, however, that many of the beetles except when actually feeding left the cress beds and sheltered in the long grass on the adjoining banks. This long grass therefore was sprayed lightly with paraffin during sunny weather, when the beetles were feeding on the cress—with the object of discouraging them from leaving the beds. The stream was then blocked and the water allowed to cover the cress completely. Later the water was liberated quickly and very many of the beetles were washed away.

One spraying with Derris Wash was also applied during August. The application of the two methods—flooding and spraying—was effective. Injury to the Watercress was checked, and most of the beetles appeared to have been destroyed, very few remaining on the beds by the end of August.

The control of this pest by spraying as carried out at these two centres is interesting, as owing to the very dense growth of the plants only superficial wetting with the insecticide is possible. The success of the method apparently depends largely on the preference the insect has for feeding on the tops of the plants during sunny weather. At the same time repeated sprayings are necessary because, owing to the overlapping nature of the life history, eggs, larvae and adults are present and the former are likely to be unaffected. Many of the larvae also feed on the under sides of the leaves and lower down on the plant, and will escape the effects of the spray.

Summary.

1. Two cases of severe injury to Watercress by the beetle *Phaedon cochleariae* are recorded.

2. Control was obtained at one centre by spraying the beds with suitable insecticides—Derris and Pyrethrum sprays being used. It was undesirable to use arsenical sprays.

3. At a second centre a large measure of control was obtained by flooding the beds—many of the beetles being washed away when the water was released.

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ABSTRACTS, REVIEWS, AND BIBLIOGRAPHICAL NOTES.

AGRICULTURAL ECONOMICS.

Abstractors:

J. PRYSE HOWELL, M.Sc., J. GLYNNE WILLIAMS, B.Sc., M.S.

ACCOUNTS AND COSTS.

Dairy Farming in the Blackmore Vale.

Survey Studies No. 1. G. B. BISSET, C. PRINGLE and EDGAR THOMAS, The University, Reading, Department of Agricultural Economics.

This is a survey made of farming conditions during the year 1929 in the Sturminster district of north-west Dorset. The total number of farms surveyed was 288, having a total area of 31,504 acres. About 80 per cent. consisted of small and medium sized "family" farms of less than 150 acres. Of the total 62 per cent. were tenant farmers, 25 per cent. were owner occupiers, and 3 per cent. partly owners and partly tenants. About 91 per cent. of the total farm area was under permanent pasture, and dairy farming the major enterprise—62 per cent. of the total farm income being derived from the sale of dairy produce. Of the estimated total "saleable" milk output on these farms, approximately 61 per cent. was produced during the six summer months, and 39 per cent. during the six winter months. Of this output about 87 per cent. was disposed of in liquid form and most of it was destined for the wholesale milk trade. A very high percentage of the milk sold wholesale was sent to the local factories. Attention is drawn to the great variety of wholesale prices ruling in the area, and the range of prices is illustrated in two tables—one showing the actual monthly prices received by eighty farmers and one showing eleven different contracts obtained by twenty-two farmers supplying the same factory.

The cost of milk production on eighty-seven milk-selling farms and on twenty cheese-making farms are examined. These costs have been calculated on the assumption that all the farms are milk producing units and all costs have been charged to milk production. The limitations of the method are stressed. The cost per gallon of milk shows great variations from farm to farm, and the factors influencing these differences in costs are discussed. Emphasis is laid on the advantages of the well balanced business and in particular on the need for securing the optimum ratio between the size of farm (determining the overhead costs), the size of herd and the labour complement.

While cheese-making has declined considerably in this area, the results indicate that the average net return from the milk-selling farms is lower than for those engaged in cheese-making.

J.P.H.

Hertfordshire Agriculture; An economic survey of

R. McG. CARSLAW. Report No. 18. Cambridge School of Agriculture

This study is based on records collected in the autumn of 1930, and the data was obtained by what is generally described as the "survey" technique. The results relate to 320 farms selected from 3,300

holdings in Hertfordshire, and the method of selection adopted is explained in a preliminary chapter. Complete records were obtained for 303 farms, and after allowing for the farmers' own labour (average £188 per holding) interest on farm capital at 5 per cent. (average £97 per holding), use of dwelling house, and a certain amount of farm produce and other materials (average £70 per holding) the average "profit surplus" per holding was a *minus* figure of £180.

The capital value of land, buildings and improvements was about £21 per acre, and rents averaged 21s. 8d. per acre. The Michaelmas value of tenants' capital (live and dead stock and tenant right) was approximately £10 per acre, and of this 43 per cent. was represented by livestock, 37 per cent. by crops and tenant right, and 20 per cent. by implements, machinery and appliances. Of the gross income, which averaged £8 per acre, 72 per cent. was represented by the sale of livestock and livestock products (dairy produce alone accounting for 29 per cent. of the sales), 25 per cent. from crops, and 3 per cent. from other sources of income. About 56 per cent. of the land is arable and more than half this is under cereals. But only 25 per cent. of the crop produce is marketed direct, the remainder being used for the feeding of livestock and for seed. Of the arable area there is approximately 14 per cent. under wheat and nearly three-quarters of the produce is sold. Oats account for 12½ per cent. and barley 4½ per cent. of the farmed land. The two principal cash crops in the "fallow shift" are potatoes and sugar beet.

The section dealing with the farm expenses shows that labour accounts for 34 per cent. of the gross costs, purchased foods 17 per cent., rent 14 per cent., purchased livestock 14 per cent., fertilisers 4 per cent., seeds and implements 6 per cent., and other items 11 per cent. There is considerable scope for increasing labour efficiency by the modernisation of power and equipment, and it is suggested that the more general use of tractors and the application of electricity to agriculture indicate ways for increased efficiency. It appears that nine-tenths of the farm profits in Hertfordshire during 1930 were covered by five factors, in this order of importance: (1) Efficiency of labour, measured in terms of the gross output per £100 worth of labour; (2) The rate of capital turnover; (3) Efficiency of livestock production measured in terms of the gross livestock output per £100 worth of foods; (4) Size of farm measured in terms of the gross output; (5) The value of the dairy produce sales. On farms which were below normal in all factors, the average labour income for the group was *minus* £321. Fifty per cent. of the farms were above normal in Factor 1, and the labour income was *plus* £203. Farms which were above normal in Factors 1 and 2 showed a labour income of *plus* £269, while farms which were above normal in the first three Factors had a labour income of *plus* £336. Only one-eighth of the farms were above normal in four factors, and only one-ninth in all five Factors and the labour income averaged *plus* £463 and *plus* £499 respectively. It is stated that these analyses only illustrate that there is a *marked tendency* for a certain effect to be produced by a certain cause but do not allow dogmatism in individual cases.

J.P.H.

Potatoes and Root Crops; Cost of production and financial results, 1924 to 1929.

Report No. 12. JAMES WYLLIE, South Eastern Agricultural College, Wye, Kent.

Financial results are given for 660 acres of potatoes on ten farms, 588 acres of mangels on eighteen farms, and 645 acres of other root crops on eleven farms for the years 1924 to 1929. The general structure of a cost account for these crops is described and the method of dealing with manurial values and beneficial cultivation is discussed. Separate costs are given for potatoes, mangels and cabbage, and for roots carted off and those chiefly folded off by sheep.

The average yield of potatoes was 6 tons, 7 cwts., produced at an average cost per acre of £34 9s. 5d. or £6 0s. 5d. per ton; and 79 per cent. was sold as ware and seed at an average price of £5 9s. 6d. per ton. Only one farm showed a profit (15s. 8d. per acre), while the other nine showed losses ranging from £2 3s. 7d. to £8 17s. 3d. per acre.

The total loss on the crop over the years under review was £4 7s. 2d. per acre or 13s. 8d. per ton. Labour and equipment represent 52 per cent. of the total net cost, seed 19 per cent., manures 20 per cent., and sundry items 4 per cent. It is emphasised that with the existing methods of cultivation the scope for reducing costs per acre is very limited. Of mangels, the average cost per acre was £24 8s. 3d. and 18s. 9d. per ton for an average yield of about 26 tons per acre. The component parts of the costs were: Labour and equipment 65 per cent., manures 23 per cent., and 12 per cent. for other items. Attention is drawn to the importance of both cost per acre and yield per acre in determining the cost per ton. The weakness of mangels as a cleaning crop and the need for finding other more economical methods of keeping the land clean are discussed.

For nine farms the net cost of growing "other roots" varied from £4 14s. 11d. to £19 5s. 2d. per acre, and the results for two farms showed the average cost of growing cattle cabbage was about £23 and the approximate yield per acre was about 23 tons. J.P.H.

Scotland; The Profitableness of farming in

(Report on the financial results obtained on certain groups of farms in Scotland in 1928-29, with a statistical account of the farms in the counties of Berwick, Roxburgh and Selkirk). Department of Agriculture for Scotland.

This publication is the first of what is intended to be an annual series dealing with the profitableness (or otherwise) of farming in Scotland. Four main branches of farming have been investigated, and the annual statistics collected by the Department (relating to the acreage, yield of main crops and the number and distribution of livestock according to their classes on each holding) were used as a guide in fixing the farming types. The regions selected embrace the meat (mainly beef) producing areas of the north-east, the crop producing areas of the east, the dairy farming of the south-west, and the Border district, which is concerned chiefly with the maintenance of ewe flocks and the feeding of sheep. The first part of the report deals with these returns of transactions under the headings of (1) general description of the farm, (2) Economic organisation of the farms, (3) Financial results,

(4) Factors underlying differences in profits, (5) Adjustments suggested by present levels of prices and of costs.

The results indicate that the livestock industry of the north-east and the dairy farming of the west and south-west come out best. The cattle feeding farms show an average profit of £216, and this has to cover managerial and manual work and the use of capital amounting to £3,300. Of the dairy farms in the south-west, an average profit of £326 was obtained, or 10.2 per cent. on the average capital invested, if the farmer's work is not taken into account. It is stated that the "Labour Income" is on the average a negative amount in the east and Border areas, and less than a labourer's wage in the north-east, and that it is only on the dairy farms in the south-west area that the average "labour income" might be considered reasonably adequate by a proportion of the farmers engaged.

The second part of the report contains a statistical account of farms in the border counties of Berwick, Roxburgh and Selkirk and their classification. This study, while contributing to the technique of economic investigation in the field of agriculture, has as its main objective the means by which groups of farms can be selected for the purpose of accounting data so that a balanced view of the industry as a whole can be obtained. This is the first of similar investigations which are being carried out, and the statistics given in this study are supplementary to the reports issued annually by the Department of Agriculture on the acreage of crops and livestock in Scotland.

Dr. J. S. King, the Advisory Officer on Farm Economy to the Scottish Board of Agriculture, has to a large extent planned and executed this enquiry, and in the collection and the balancing of the farm accounts the Department has had the co-operation of the Agricultural Economists at the three Scottish Colleges of Agriculture.

J.P.H.

Sheep Breeding and Feeding over four years, 1926-27 to 1929-30.

Report No. 11. James Wyllie and N. V. Hewison. South Eastern Agricultural College, Wye, Kent.

Part I deals with the management and the changes which have been made in the sheep enterprise during the four years on the College Farm at Wye. The fattening of sheep as a separate enterprise was abandoned because the accounts showed that under College farm conditions the prospects for breeding were much better than for fattening. Folding crops such as kale, etc., were discontinued and Half-bred and Kerry Hill ewes were introduced with a view of maximising the lamb crop.

Part II deals with the financial results from sheep husbandry during this four years period. The results show that the profit per ewe per annum was 13s. 9d. for the Half-breds, 9s. for the Kents, and 9s. 1d. for the Kerry Hill. There was a loss of 4s. 6d. per lamb on the Dorset Horn flock. On the capital invested the Half-breds showed a profit of 17.7 per cent., the Kents 14.3 per cent., Kerry Hills 11.2 per cent., and there was a loss of 6.4 per cent. on the Dorset Horn.

The number of lambs sold or transferred into the flocks per 100 ewes put to the ram was 138 for the Half-bred ewes, 105 for the Kents, 129 for the Kerry Hill and 111 for the Dorset Horn. Of the lambs sold or transferred an average price of 46s. 9d. was realised for the Half-breds, 42s. 11d. for the Kents, 49s. 7d. for the Kerry Hill and

58s. 10d. for the Dorset Horn. The annual depreciation on the ewes was 14s. 10d. for the Half-breds, 4s. 8d. for the Kents, 22s. 6d. for the Kerry Hills and 17s. 9d. for the Dorset Horns. Of the ewes put to the rams the death rate averaged 7.1 per cent. for the Half-breds, 5.2 per cent. for the Kent, 14.3 per cent. for the Kerry Hills, and 11.9 per cent. for the Dorset Horns.

Attention is drawn to the fact that the Half-bred flock consists of young ewes and that a higher output of lambs may reasonably be expected when it contains the normal proportion of ewes of different ages. As regards the Kerry Hill sheep, it is maintained that as the flock has been on the farms only for two years that fair average results have not yet been obtained. Despite the high average prices obtained for the lambs at Easter, the Dorset Horn was not able to compete financially with the grassland sheep, and for that reason the flock was sold. The returns from the fattening sheep were very unsatisfactory, and showed an average loss on the capital invested of 24 per cent. or 51.9 per cent. per annum on the gross output. This loss is attributed to the disparity between the price level of the sheep bought and that of the sheep sold.

The Report contains a revenue account for each class of flock kept, together with some other useful data pertaining to sheep husbandry on the College farm. J.P.H.

Strawberry Growing in South Hants; Financial results of, 1931.

Agricultural Economics Department, University of Reading.

This interim report summarizes the financial results obtained from the 1931 strawberry crop by 350 growers, all of whom were members of the Swanwick and District Fruit Growers' Association, Limited.

The total area of strawberries grown by the 350 growers in 1931 season was 1312.5 acres, or an average of 3.75 acres per grower, and the average yield was 1.37 tons per acre. The bulk of the fruit was sold wholesale for dessert purposes, only 3.9 per cent. was sold for jam, and 0.9 per cent. was sold off the ground to passing customers or retailed by growers locally.

The total cost of growing and marketing the crop was £68 9s. 9d. per acre or 4.97d. per lb. of fruit (including charges for family labour). Omitting cost of family labour, the total cost was £48 16s. 1d. per acre, or 3.82d. per lb. About one half the actual expenditure was incurred previous to picking and one half for picking and marketing.

The net receipts averaged £55 14s. 2d. per acre, or 4.35d. per lb. of fruit sold. Profits averaged £6 18s. 1d. per acre, or 0.54d. per lb. of fruit, but when family labour was assessed at current wage rates there was a loss shown of £7 15s. 7d. per acre or 0.61d. per lb. It is stated that the growers on the whole did not do badly and some, even after allowing for family labour, were able to show an appreciable profit balance. J.P.H.

University of Bristol, Department of Agriculture and Horticulture, Economics Branch.

(Mimeographed Bulletins).

Issue No. 1.—List of farms. February, 1931.

Issue No. 2.—Production in relation to capital and costs. Based upon accounts for cropping year 1929. February, 1931.

Issue No. 3.—Influence of arable upon production. Based on accounts for cropping year 1929. July, 1931.

Issue No. 4.—Wiltshire Agricultural Accounting Society. Factors affecting Wiltshire profits. Based upon accounts for cropping year 1930. February, 1932.

Bulletin No. 6.—Sugar Beet; Cost of production of in Hereford and Worcester, 1925-26 to 1929-30. By C. V. DAWE and GORDEN P. HAYES.

Bulletin No. 7.—A Bulletin for Somerset farmers, 1925-29. Part I (Introduction, Cropping, Marketing). By G. T. ROY.

Issue No. 1 contains a list of farms arranged in numerical succession county by county. The data is set out in tabular form under the headings—Farm No., soil, acres, owned or rented, percentage gross production, market town, and accounting year ends.

Issue No. 2 deals in a broad way with the results of the crop year 1929, with figures for eighty farms. It is divided into four chapters as follows: (1) Statistics for capital costs, production and profit or loss; (2) Relation of production to capital and cost; (3) Estimates of production compared with actual results; (4) The field for further investigation. *Issue No.* 3 treats with the influence of arable upon production and the results are based upon accounts for the cropping year 1929. There are 108 farms included in the tables, but only 100 farms have been included in the calculations. The results are discussed under five chapters: (1) Figures for production, capital costs, labour, and arable; (2) Relation of production to capital costs, costs and labour; (3) Influence of arable upon the foregoing relations; (4) Calculated production compared with actual production; (5) In conclusion. *Issue* No. 4 deals with the factors affecting Wiltshire profits (Wiltshire Agricultural Accounting Society) for the cropping year 1930. An analysis is made of the effect of twelve factors upon (*a*) production per acre; (*b*) costs per acre; and from these (*c*) profit or loss per acre.

Bulletin No. 6.

This Bulletin contains the results of the costs of production of Sugar Beet in Herefordshire and Worcestershire for the period 1925-26 to 1929-30. The evidence given in this report shows that since 1926 there has been a consistent fall in the cost of production, which leads to the conclusion that growers are rapidly forming knowledge in the handling of this crop. Over the period of four years the average cost of production on all types of soils has been £26 per acre. On light soils the cost was £24, on medium soils £25, and on heavy soils £28 per acre. While higher yields were obtained on the heavier soils, the increase was not sufficient to alter the relative position of the three soil types when costs are considered on a tonnage basis. The position is as follows:—

Soil Type.	*Yield Washed Beet.*	*Cost per ton.*
	Tons.	s. d.
Light	9.45	53 0
Medium	9.55	54 0
Heavy	9.55	55 8

The average of four years' results for all types of soil show that labour (horse, manual and tractor) represented 55 per cent. of the total costs. As a rough guide it is stated that an acre of sugar beet required

about 260 hours of manual and 110 hours of horse labour and that one-half of the manual and one-third of the horse labour was incurred during the harvesting period. It is also stated that about forty hours less manual hours per acre was required on the light as compared with the heavy soils. Very little use was made of tractors, probably because the average size of the crop was only eleven acres and economical working was not possible. The report gives a fair amount of information on the important question of manuring. Farmyard manure was applied on only half the crop and at the rate of 8 to 11 tons per acre and it is indicated that the application of farmyard manure had the effect of slightly increasing the yield of the roots and the percentage of sugar. Artificial manure was applied in all cases and the average expenditure for all soil types was 84s. 9d. per acre.

The question of type of soil, quantity sown, dates of drilling and singling as affecting yield is commented upon.

For all soil types and over a period of four years the average yield of washed beet works out at 9 ton 13 cwt. per acre, with an average sugar content of 17.75 per cent. The time at which the crop is harvested appears to affect the percentage of sugar—late harvesting tending to reduce the sugar content.

Bulletin No. 7.

It is stated in this bulletin for Somerset farmers, that although more than one hundred farm accounts have been collected each year, it is only for eighty-two cases that the results can be followed through the whole period under review, and for that reason it is only these results that are discussed in this issue. The period studied is from 1925-26 to 1928-29 inclusive—chosen because it covers one complete cropping rotation under a four years system. The bulletin contains an explanation of the terms used in farm book-keeping, how the farms have been divided up into different farm types, a study of the farms in relation to the chief markets in Somerset and a study of the effect of size, cropping and general farming method on the profit or loss. J.P.H.

Yorkshire Farms; Eight years records of production, production costs, source of supply and method of disposal of agricultural products. ARTHUR G. RUSTON and HERBERT E. NICHOLS, The University, Leeds.

This study is based on records collected from a large number of farms in Yorkshire during the years 1921-29. The results indicate that the yearly variations in the type and monetary value of the agricultural output from these farms tend more and more to a reliance upon stock; the monetary value of stock products being 49 per cent. of the total in 1921-22 and 71 per cent. in 1928-29. Throughout this period the dairy herd has taken a prominent part and over a series of nine years the receipts from milk and dairy products represented 25 per cent. of the total output from these holdings and 30 per cent. in 1928-29. Increased attention has of late been given to the pigs and poultry enterprises. The value of the eggs and poultry sold was 2 per cent. of the total output in 1921-22 and 6 per cent. in 1928-29, and pig sales represented 10 per cent of the total output in the former and 14 per cent. in the latter year. Owing to falling prices, the proportionate value of the cereal crops has been reduced from 24 per cent. of the total in 1921-22 to 14 per cent. in 1928-29 and it is indicated that more attention is given to the growing of such crops as potatoes, carrots, peas for picking green, and sugar beet.

Production costs for these farms on an eight years average basis were £777 per 100 acres. Of these, Labour formed 32.2 per cent. of the total, Purchased Food 24 per cent., Rent and Rates 18 per cent., Fertilisers and Seed 10.8 per cent., and upkeep of Implements and Tradesman Bills 15.5 per cent. The total farm output or production for the same period averaged £788 per 100 acres and 64.9 per cent. was represented by stock products and 35.1 per cent. by crop products. A summary of the "Social Output" shows that £377 per 100 acres, or £3 15s. 3d. per acre, was the average amount available for distribution among the workmen, landlord and farmer, and of this 66 per cent. was taken to meet the wage bill, 31 per cent. to pay the rent, leaving only 3 per cent. available for the farmer to meet interest on capital and managerial charges.

Costs of individual products (crops and livestock) are fully discussed and commented upon. Included also are horse labour costs for each year and the average costs over an eight-year period, together with a comparison of cost of horse labour on holdings of different sizes in Denmark with those obtained for similar farms in Yorkshire. While there has been a tendency to lay down land to grass, there has not been a corresponding reduction in the number of work horses kept, and this has resulted in a decrease in the number of working days per horse. No marked modification in the feeding of working horses is found, with the result that there is an increase in the cost of horse labour which is out of all proportion to its economic value. J.P.H.

MARKETING; CO-OPERATION; PRICES.

Apples in Michigan; Consumer demand for

H. P. GASTON. *Special Bulletin*, No. 209, Agricultural Experiment Station, East Lansing, Michigan.

Whilst the results in this bulletin are mainly of local interest, the method of investigation and the possibility of its application in a modified form in this country is worthy of study. "Believing that no other source of information could compare with that obtained while actually selling apples, much of the writer's time was spent in acting as clerk . . . In each case the observer was presented to the trade as merely a new clerk, who had been added to the sales force". The detailed information gained in this unique experience is placed before the reader, outlining the many and varied eccentricities of the ultimate consumers which affect the final demand. The producers' interest in this publication is found in the method, or lack of method, in reflecting back these characteristics of demand, so that he may adapt his productive methods to suit market demand. J.G.W.

Dairy Products; Co-operative Marketing of

HARRY G. ANDERSON and ALVA B. BENTON. *Bulletin* 238, Agricultural Experiment Station, North Dakota.

This is a detailed study of the main features of the organised manufacture and sale of butter in North Dakota and North Western Minnesota. Scattered throughout the area are Cream Shipping Associations and as their name implies they act as collecting agencies for cream, which is delivered to a central creamery. Three types are mentioned, Centralised cream stations, Independent cream stations, and Farmers' co-operative cream stations. The organisation, operating

methods and costs of the latter type are discussed in detail and a brief summary of the basis for their successful operation is added.

The organisation and financial problems of the Co-operative creameries are discussed in Part II. Interesting discussions on the problem of efficiency in butter making and the factors affecting the price paid by creameries, *e.g.*, overrun, margins, and butter prices, are included.

Part III gives a brief history of the Land o' Lakes Creameries Inc., a federation of co-operative creameries. A detailed statement of the activities of this central sales association is given and the achievements in the improvement of quality and development of standardisation are emphasised. This improvement can be summed up by stating that 28 per cent. of total butter received graded ninety-three or better in 1920, whereas in 1929 the proportion was 70 per cent. It is unfortunate that there is no discussion or statement of costs and general expenses as in the cases of the Cream shipping associations and the Co-operative creameries. J.G.W.

Fertilizer Control in Vermont; A half century of
Feeding Stuff inspection; A third of a century of

J. L. Hills, University of Vermont and State Agricultural College, Vermont. *Bulletins*, 323 and 324.

The laws controlling the sales of fertilizers and feeding stuffs in Vermont insist upon the manufacturer "stating what he sells and selling what he states". These bulletins contain a brief review of the pre-law situation, that existing when inspection had been in vogue a few years, and that obtaining to-day after years of development and experience. An interesting feature are the lists of results of analyses showing the number which met the guarantee given and the failures, together with the causes for such failure and a suggestive discussion upon the marked success of certain firms. J.G.W.

Fruit; Report on preparation for market.

(Part II. Gooseberries, Currants, Cherries, Raspberries, Loganberries, Tomatoes, Cucumbers, and Grapes). *Economic Series*, No. 24. Ministry of Agriculture. H.M. Stationery Office, London, 1931.

This report completes a triology on Fruit Marketing in England and Wales. The first Report (*Economic Series*, No. 15) dealt with the trade as a whole. It was followed by a Report (*Economic Series*, No. 21) setting out in detail the best commercial practice in the preparation for market of apples, peas, plums, and strawberries. The present Report fulfils a similar purpose in relation to the remainder of the fruit produced in this country for commercial purposes. It is mainly intended for the guidance of growers and packers, but it contains much valuable information of interest to all connected with the marketing of fruit. J.G.W.

Illinois farm products; Prices from 1866 to 1929.

L. J. Norton and B. B. Wilson. *Bulletin*, No. 351. University of Illinois, Urbana.

This is an attempt to build up a comprehensive series of price quotations for the various products of Illinois farms. The two main sources of data were newspaper market reports and actual records of dealers' transactions in the area. Owing to the difficulties involved in

collecting the scattered information in the diaries and accounts of individual farmers, they were not used. For each commodity the available average prices for certain commodities are shown, together with an average quotation for the State. This is followed by a brief discussion of the fluctuations and the changes in production.

The study is chiefly of historical value, but places in the hands of economists and others valuable data in an available form. J.G.W.

Ireland; Agricultural Co-operation in

A survey by the Horace Plunkett Foundation. Pub. by Routledge and Sons, Ltd.

This is a further contribution of the Horace Plunkett Foundation to its series of surveys of the Agricultural Co-operative Movement in different countries. The major portion of the book is devoted to a brief description of each individual co-operative society in the country, outlining the nature of trade, membership, and financial position.

The importance of the movement in Ireland is shown in the statistical summary; there are 302 co-operative creameries, with an annual trade in dairy produce of nearly £6,000,000, and 131 other organisations dealing in agricultural requirements, eggs and poultry, pigs and meat, and flax and wool. In all, there are 433 societies with over 107,000 members doing a trade of nearly £9,000,000 per annum; in addition, there are ninety-nine agricultural credit societies.

The two chapters on co-operative creameries which outline the development, organisation and State policy are of particular interest to farmers in Wales at the present time and give an excellent picture of the co-operative attempts to deal with the problem of the marketing of dairy produce in Ireland. The detailed discussions on finance and credit, selling problems, especially the question of a central sales agency, and also the problem of winter dairying place before the reader an interesting discussion upon the practical aspects of the general problem.

The final chapter on central organisations and their relation to the movement contain stimulating criticisms of the existing organisations and constructive suggestions for future development.

The book is an opportune discussion of the achievements of agricultural co-operation, although it appears that an undue proportion has been devoted to the description of individual societies and the important topic of the history and development of the movement has been limited to eighteen pages. J.G.W.

Potato Marketing; Report on the organisation of

Economic Series, No. 34. Ministry of Agriculture. H.M. Stationery Office, London, 1931.

This series of " orange " books has, in the past, been devoted mainly to providing a picture of the existing marketing system for the various agricultural products, and the study of the possibilities of introducing some methods of standardisation. The marketing of potatoes has been described in detail in Report No. 9 of the Series, and this further book on potatoes marks a new departure from past policy. The most important agricultural commodities of this country have been dealt with and it appears that the further issues will be devoted to an examination of the possibilities of organisation, based upon the information previously published.

The approach to the problem of the re-organisation of potatoes is interesting. The Report reviews the present position in England and Wales and then outlines briefly the methods adopted in foreign countries in organising and regulating the trade. Each country has its particular problems, but the physical aspect of marketing is similar throughout. Five recent developments in potato marketing in this country are reviewed and three schemes which have been suggested are outlined. The promoters of these developments and schemes were unable to take advantage of the powers incorporated in the Agricultural Marketing Act 1931, and the main feature of the plan of development outlined in this book is that these powers are now available should there be a desire to use them.

As a guide to the improvement in the marketing of potatoes in this country by a board constituted under the Agricultural Marketing Act this book is particularly helpful; but it also provides an excellent review of the general problems regardless of whether the suggested plan of development is acceptable or not. It should be read, together with No. 9 of the Series on the " Marketing of Potatoes ", by all interested in potato production and marketing. J.G.W.

Sugar Beet; Report on the industry at home and abroad.

Economic Series, No. 27. Ministry of Agriculture. H.M. Stationery Office, London.

This well-known series of " Orange Books " has dealt mainly with the marketing problems of various agricultural products and has, therefore, become generally recognised as devoted purely to marketing studies. This report demands special notification as being a departure from the generally accepted practice. As the title implies, it is a comprehensive survey of the industry both at home and abroad and its inclusion in the Economic Series of the Ministry of Agriculture permits it to be placed in the hands of the general public at a remarkably low price.

The history of the industry both at home and abroad is reviewed in detail, and it is interesting to note " that, in every case where it has been successfully established, it has been fostered by State subventions in its infancy ". The methods adopted by the various authorities in granting this assistance are particularly interesting and the influence of such upon the agricultural industry and the beet sugar industry is reviewed in detail.

To all interested in arable farming and the possibility of producing sugar beet, this publication is extremely valuable. Farmers in Wales, not necessarily interested in sugar beet, will however, find the report interesting as it gives an excellent account of the vicissitudes of an industry clamouring for government assistance and the effects of such assistance when granted. J.G.W.

WOOL.

Kent Sheep; Economy of washing before shearing.

N. I. TINLEY, South-Eastern Agric. College, Wye, Kent. *Journal of Ministry of Agriculture and Fisheries*, Vol. XXXVIII, No. 2, May, 1931.

The Kent Woolgrowers Ltd., who handle some 250,000 fleeces per annum grade the fleeces into nineteen grades of greasy wool and nineteen corresponding grades of washed wool. The average results for five

years show that the loss in weight due to washing was 12 per cent. in the case of ewes (7.77 lb. reduced to 6.88 lb.) and 17 per cent. in the case of tegs or yearlings (6.72 lb. reduced to 5.58 lb.). None of them had been folded on roots. The cost of washing was estimated to be 2d. a ewe, allowing for a loss of one in 500. The difference in price between the washed and greasy wool was about 2½d. a lb.

The actual returns from 1,000 lb. of greasy ewe wool and the equivalent quantity of washed ewe wool of the same grade is given. The increased returns due to washing per 1,000 lb. of greasy wool were as follows in the five years under investigation:—

17/8; £1/14/2; £3/19/0; £1/1/3; £3/0/2.

Thus, the owner of a flock of about 130 ewes would have secured an increased return of about £8 10s. in the five years, from which would have to be deducted the cost of five washings. R.G.W.

ANIMAL NUTRITION.

Abstractor:

R. O. DAVIES, M.Sc., University College, Aberystwyth.

Baby Beef; The Rationing of.

R. H. COMMON. *J. Min. Agr. N. Ireland*, 1931, 3, 34-48.

No support was found in these experiments for the opinion that the use of large amounts of expensive nitrogenous cakes is an essential point in the feeding of Baby Beef animals. In every case the rations used contained a very large proportion of home grown foodstuffs. A mixture of four parts bruised oats and one part decorticated earthnut cake was found to be satisfactory, and no advantage was obtained by increasing the proportion of cake. The use of decorticated earthnut cake in these experiments was determined by the ruling price of this feeding stuff, and home grown oats were used in order to increase the proportion of home grown foodstuffs in the rations. The calves in this experiment were dropped between March 3 and May 5, 1929, the experimental period beginning in October, 1929, and concluding in May, 1930.

R.O.D.

Beet Leaves; Investigations concerning the Food Value of.

F. HONCAMP and W. SCHRARUM. *Tierernährung*, 1931, 3, 174-207.

The leaves should be washed before drying, feeding or cutting for sillage. Washing does appreciably diminish the food value.

R.O.D.

Beet Leaves; Ensilage of.

G. RUSCHMANN and G. GRÄF. *Bied. Zentr.*, 1931, 60A, 17-8.

The effects of feeding beet leaves to milch cows are examined. In certain district beet leaves had a higher oxalate content than normal and were alkaline. The oxalate content was considerably reduced by ensiling. The cold fermented material still produced injurious effects, which are ascribed to the high nitrate content of the leaves. More suitable fertilisation of the growing beets with reduced dressing of nitrate of soda is recommended for the production of leaves of lower oxalate and nitrate content. R.O.D.

Chickens; Nutritional Factors influencing the Growth of.

R. G. BASKETT and J. H. PRENTICE. *J. Min. Agr. N. Ireland*, 1931, 8, 1-33.

Details of extensive poultry experiments ranging over several years at the Northern Ireland Research Stations are given. The following conclusions are drawn:—

1. That the best rearing ration consists of a mash of mixed cereal meals, scratch grain, and as much clean separated milk as the birds can drink.

2. That a mineral mixture is capable of giving 75 per cent. of the results obtained from separated milk.

3. There is evidence that milk fat has no special value in the rearing of chickens.

4. The trials with vegetable protein and animal protein indicate that vegetable protein was capable of giving as good liveweight gains as animal protein, provided that a suitable supplement of mineral material was provided, but the evidence suggests that all vegetable proteins were not equally suitable. Soya bean meal proved a very satisfactory source of protein. Efforts which are still in progress to design a mash capable of replacing milk indicate that the addition of 18 per cent. of extracted soya bean meal to the cereal meals and minerals constitutes a mash which will give for practical purposes as good results as those obtained with milk.

5. Considerable progress has been made with the problem of simplifying the mineral mixture. When oyster shell grit is provided *ad. lib.*, salt and muriate of potash are the only minerals necessary to carry the birds to the laying stage. Definite conclusions are withheld in so far as laying is concerned until the birds have been laying for two years.

R.O.D.

Chick; Studies in Protein Nutrition of the.

MCFARLANE, GRAHAM, and HALL. *J. Nutrition*, 1931, 4, 331-49.

Equal amounts of crude protein from buttermilk powder, fish meal or meat meal had practically the same effect on growth when supplementing a basal diet. The mortality was high with the fish and meat meals. The protein of cod-liver meal was found to be biologically inferior so far as growth was concerned. Normal chicks do not grow on a diet on which the sole source of protein is of animal origin. White rice or other vegetable protein appears necessary to the nutritional requirement of chicks. The responsible factor present in vegetables is unknown. R.O.D.

Cod-Liver Meal; Vitamin Value of.

HOLMES, PIGOTT and MENARD. *J. Nutrition*, 1931, 4, 193-201.

The best cod-liver meals produced about the same results when 2 per cent. was added to the basal ration as when 0.5 per cent. of cod-liver oil was added. The poorer meals possessed little if any vitamin value. R.O.D.

Dairy Cattle; Long time Mineral feeding Experiment with.

C. F. HUFFMAN and O. E. REED. *Mich. Agric. Expt. St. Circ. Bull.*, 129 (1930).

Mineral supplement of calcium to an average ration of timothy hay, silage and grain for cows was unnecessary. Supplements of bone

meal improved the general health and milk production of the animals, though there was no effect on the duration of the lactation period or on susceptibility to infection (notably by *B. abortus*) Prolonged feeding of rock phosphates injured the health and caused the formation of abnormal and badly worn teeth and enlargement and roughening of the jaw and leg bones. Supplements of limestone produced no adverse effects. R.O.D.

Digestibility and Feeding Value of Cereals; Effects of various methods of preparation on.

N. HANSSON, *Bied. Zentr.*, 1931, B, 3, 243-74.

In feeding trials with pigs the digestibility of cereals was increased up to 18 per cent. by grinding. The digestibility and feeding value of whole or ground cereals was not increased by soaking in water, and was only slightly increased by cooking. The feeding of maize (up to 75 per cent. of the concentrates) to pigs did not affect the firmness of the lard produced. R.O.D.

Grassland Management; Investigations into the Intensive System of. II, The Mineral Content of intensively treated pasture. III, Seasonal Variation in the Mineral Content of Pasture, with particular reference to drought.

GREENHILL, PAGE and FERGUSON. *J. Agr. Sci.*, 1931, 21, 220-40.

Under intensive grassland management, the phosphoric acid content of pasture representing three to five weeks' growth showed a definite seasonal variation. It fell during drought or the early summer flush period and recovered after the drought or flush period respectively. The phosphoric acid showed consistently a highly significant positive correlation with the nitrogen content of the herbage. A non-intensive pasture of good quality contained less total ash and phosphoric acid than the intensive pastures, though similar lime and silica contents.

Samples of pastures collected during 1929 show that the drought conditions of that summer seriously affected the mineral composition. The nitrogen content was also affected, low values being obtained during the drought and high values at the end of the year. R.O.D.

Dreg Meal; The Digestibility and Feeding Value of.

S. J. WATSON. *J. Agr. Sci.*, 1931, 21, 410-3.

When distillers' dregs are dried, they form the highly concentrated foodstuff known as dreg meal. The feeding value and digestibility of this meal is such that it may replace linseed cake. Owing to its high oil content, however, it should be used with caution and cattle should not receive a greater allowance than 4-5 lb. per head per day. Owing to its low fibre content, it should be a suitable foodstuff for pigs as well as cattle and when the price is favourable would form a useful source of protein in the ration. R.O.D.

Grassland Management; Investigations into the Intensive System of. IV—VII, The Digestibility and Feeding Value of Artificially dried Grass and of Grass Silage.

S. J. WATSON. *J. Agr. Sci.*, 1931, 21, 414-41, 452-7, 469-75.

Digestibility trials are described with sheep on a sample of dried grass and a grass meal, both of which were artificially dried on an experimental band drier. The digestibility was of a high order, the

material being superior to excellent hay. A feeding trial with dairy cows showed that the artificially dried grass was readily eaten by dairy cows and would produce the quantity of milk for which the nutrients it supplied were theoretically capable.

It has been found that the making of stack silage is a useful method of conserving surplus grass. The silage was fed to stock with satisfactory results and formed a large proportion of their winter ration. Silage has also been made satisfactorily in a pit from grass cut at the flowering stage when it was impossible to make hay. The silage was eaten readily by dairy cows. R.O.D.

Mare's Milk; The Composition of.

R. G. LINTON. *J. Agr. Sci.*, 1931, 21, 669-88.

The average composition of the milk of British mares has been found to be in close agreement with that of continental mares, with the exception of the mineral content. In the lighter British breeds (Ponies and Thoroughbreds) the ash content is similar to that of the continental mares, whereas in the heavier breeds (Clydesdales and Shires) the percentage of ash is appreciably greater.

Included in the samples examined were some from mares whose foals were not thriving, some of these milks were found to be abnormal. Mares that secrete milk with a high percentage of fat do not rear these foals satisfactorily. On the other hand, foals appear to thrive well if the milk contains very little fat. The colostrum of mares was found to have the same characteristics as the colostrum of cows. R.O.D.

Pasture Grass; Composition of.

B. SJOLLEMA. *Tierernährung*, 1931, 2, 505-19.

Grass samples frequently contained 0.5—1 per cent. potassium nitrate. As high as 2 per cent. (dry basis) was observed. In about 50 per cent. of 372 tests spring grass contained 20—24.9 per cent. crude protein, and 15—18.5 per cent. pure protein. A content of 21—24 per cent. of pure protein was often found. The content of protein in pasture would often vary over 50 per cent. within a few weeks. R.O.D.

Pasture Herbage; The Influence of the Intensity of Grazing on the Yield, Composition and Nutritive Value of (Part III).

WOODMAN, NORMAN and FRENCH. *J. Agr. Sci.*, 1931, 21, 267-321.

Results up to the present show that monthly rotational grazing, with a suitable system of manuring, provides the maximum keep. Close grazing at monthly intervals has the further advantage of conferring on the herbage a " balance " which renders it much more suited to form the sole diet of farm animals.

Weekly cut herbage was richer than the monthly cuts in crude protein, and significantly poorer in crude fibre.

The lengthening of the interval of cutting to a month did not affect the digestibility of the grass constituents in the early part of the season. In a season of normal rainfall, there is a mid-season falling off in digestibility, which, however, is not very considerable. The application of sulphate of ammonia was found to depress the development of wild white clover on meadows and pastures. R.O.D.

Pastures: Mineral Content of.

B. C. ASTON. *New Zealand J. Agr.*, 1930, 41, 10-7, 90-9.

" Dopiness " in sheep seems to be connected with calcium deficiency in the Mairoa district, and it seems to be definitely established that " bush sickness " in cattle and sheep is caused by a deficiency of iron in the pasture grasses of certain areas. Deficiencies of iron and phosphorus have been established in several localities. Numerous analyses of New Zealand pasture grasses are tabulated. R.O.D.

Pig Feeding; The Value of Dried Potatoes for.

CRICHTON, GODDEN and THOMSON. *Scottish J. Agr.*, 1931, 14, 72-6.

The results of experiments carried out at the Rowett Institute are given, where the effect of drying on the feeding value of potatoes was determined, and where it was the object to ascertain whether these dried potatoes could be economically embodied in a ration for feeding pigs. The following conclusions are drawn. (1) The drying of potatoes does not appear to affect materially their digestibility or food value.

(2) Good results can be obtained from feeding dried potatoes in relatively large amounts in a ration suitably balanced with concentrates rich in protein and minerals.

(3) Dried potatoes appear to be approximately equal in feeding value to ground maize. Fed weight for weight they produce a better type of bacon pig. R.O.D.

Pig; Mineral Metabolism in the, and the Addition of Inorganic Supplements to the Pig's Diet.

E. J. SHEEHY and B. J. SENIOR. *Irish J. Agr.*, 1931, 30, 1-63.

When the major portion of the diet of a pig consists of cereals and their by-products, and when separated milk, fish meal, meat (and bone) meal are absent, the mineral constituents likely to be deficient are lime and common salt. Calcium may be usefully supplied either in the form of a phosphate (steamed bone flour or bone black) or in the form of a carbonate (precipitated chalk or ground limestone), and when used as a supplement to a ration in which cereals perdominate the carbonate form gives equally good if not better results than the phosphate form. It is only when roots and tubers form the greater part of the pig's ration that it is a necessity to give phosphates in addition to the lime and sodium chloride. When a pig ration includes separated milk to the extent of ½ gallon per pig daily, or 10 per cent. of fish meal or of a meat meal of approximitely similar composition, there is no necessity whatsoever for adding anything in the way of mineral supplement to the rations. The importance of sunlight, green food, and liver oil as sources of Vitamin D in pig raising is emphasised. It is pointed out that commercial samples of cod liver oil may, for a number of reasons, contain little or none of the vitamin, and the indiscriminate use of cod liver oil without a guarantee of its vitamin potency may yield negative results. R.O.D.

Poisoned Barley from the United States; Investigation of.

M. POPP and J. CONTZEN. *Tierernähr*, 1930, 2, 815-55.

In the autumn of 1928 pigs fed with barley from the U.S. showed symptoms of illness not observed before. Upon examination it was found that the grains were strongly attacked by micro-organisms, among which *gibberella saubinetti* were predominant. Chemical analysis showed, in

conformity with American results, an alteration in the composition of the grain. Toxic albumins and similar toxic nitrogenous products had formed, causing the illness. The infection of the barley took place during the growing period and especially in years following moist autumns, as the straw, often left to rot in the fields, forms, when putrifying, a favourable culture medium. German grain can be infected by the above mentioned organism, but does not seem toxic. R.O.D.

Poultry Feeding; New Systems of.

H. MOLYNEUX. *J. Min. Agr.*, 1931, 38, 908-9.

A summary is given of the results of an experiment with White Leghorn pullets during their first laying year, which showed that pellets give as satisfactory results as all-mash feeding. The respective advantages and disadvantages of the all-mash and pellet methods are briefly set out. R.O.D.

Scabbed Barley and Oats and their effect on various classes of Livestock.

B. H. ROCHE and G. BOHSTEDT. *Proc. Am. Soc. Animal Production*, 1930, 219-22.

Animals with complex stomachs, such as cattle and sheep, are not affected by eating barley diseased with scab (*Gibberella saubinetii*), but animals with simple stomachs, such as the horse and pig, are affected, the symptoms usually involving vomiting and refusal of food. The active toxic principle has not been isolated, but it seems to be associated with the fractions containing glucoside or basic nitrogen compounds. (See Poisoned Barley above). R.O.D.

Swine; The relative nutritive efficiency of certain Calcium Compounds with growing.

E. B. FRASER. *Sci. Agr.*, 1931, 12, 57-80.

The findings of these swine experiments show that all the calcium compounds fed, including high calcium limestone, calcium sulphate, and bone meal promoted good growth. It is pointed out that bone meal, because of its phosphorus content, has an obvious advantage over certain other non-phosphate calcium carriers under many conditions of practical feeding. R.O.D.

Swine; The Value of Tapioca Flour and Sago Pith Meal in the Nutrition of.

WOODMAN, KITCHIN, EVANS. *J. Agr. Sci.*, 1931, 21, 526-46.

It is shown that tapioca flour is one of the most digestible feeding stuffs employed in swine husbandry. In these feeding trials, the ration of the bacon pigs from 140 lb. live weight to slaughter included 40 per cent. of this product. The conclusion of earlier investigators is confirmed that tapioca flour exerts a distinctly favourable influence on the colour and texture of the carcass fat and on the quality of the bacon.

Sago pith meal, a new carbohydrate food from Malaya, may be introduced into the rations of bacon pigs up to 20 per cent. of the ration without depressing the rate of gain of live weight. It is more suitable for pigs of 100 lb. live weight or more than for younger animals.

Sago pith meal has a favourable effect on quality and conformation. Out of a total of twenty-nine carcasses from pigs which had been

given rations containing sago pith meal in partial replacement of barley meal, twenty-seven were graded as " prime ". On the other hand only five " prime " carcasses were obtained from a group of ten pigs which had received sago pith meal and bran as a substitute for middlings.

R.O.D.

Vitamins in Canned Foods. XI, A canned Food Diet.

E. F. KOHMAN, W. H. EDDY, and C. Z. GURIN. *Ind. Eng. Chem.*, 1931, 23, 1064-6.

Rats and guinea pigs fed on a diet consisting wholly of canned foods (sterilised by heat) show normal reproduction in the fifth and third generations respectively. The rate of growth (and weight at maturity) is higher than that reported as normal. R.O.D.

LIVE STOCK.

Abstractors:

Professor R. G. WHITE, M.Sc., University College, Bangor; A. D. BUCHANAN SMITH, M.A., B.Sc., M.S.A., F.R.S.E., Department of Animal Genetics, University of Edinburgh.

Average ages of Cows and Bulls in six breeds of Cattle.

A. D. BUCHANAN SMITH and O. J. ROBISON. 1931, *J. Agr. Sci.*, Vol. 21, Part I, 136-49.

From the herd book records of six leading breeds of cattle in Great Britain (Shorthorn, Aberdeen-Angus, Hereford, Ayrshire, Jersey, and British Friesian) the ages of the parents of 2,618 pedigree calves born 1925 were tabulated. The average age of cows at calving is found to be 5.722 years ± 0.04, with a standard deviation of 2.816. In four dairy breeds the average age is 5.485 years $\pm$ 0.05, while for the three beef breeds it is 6.022 $\pm$ 0.05.

The " Annual replacement percentage " is the number of heifers drafted annually into a herd or breed as first calvers expressed as a percentage of the total number of actively producing cows in the herd or breed. It is in effect the number required annually to make good the losses, and can be calculated from the average age of the cows at calving. This is found to be at least 27 per cent. and agrees substantially with the work of other investigators. The need for enquiry into the reasons for such a high replacement figure is stressed. It is pointed out that the ideal annual replacement figure is 10 per cent., but if the existing figure could be reduced by improved methods to only 16.7 per cent. it would result in a saving of £85 per annum in a herd of twenty cows. Attention is also drawn to the fact that, at the present replacement figure, there is little room for the selection on genetic grounds of females drafted into the herd. A lowering of the replacement percentage would, by giving the breeder a better chance to select his female stock, effect an improvement in the quality of pure breds.

The second part of the paper deals with the average age of bulls at the time their progeny are born. For all the breeds studied this is found to be 3.846 years $\pm$ 0.03, with a standard deviation of 1.943. For the four dairy breeds it is 3.687 $\pm$ 0.03, and for the three beef breeds it is 4.052 $\pm$ 0.04. The annual replacement figure for all breeds was found to be 54 per cent. For the dairy breeds it is 60 per cent. and for the beef breeds 49 per cent. The reasons for this are discussed,

and emphasis is laid on the fact that the early age at which bulls are disposed of does not permit breeders to employ the progeny test, which is the surest method of stock improvement. In the dairy breeds, over 80 per cent. of the bulls are disposed of before their genetic value can be recognised. No significant difference was found in the proportion of the sexes of the calves in relation to the ages of their parents.

A.D.B.S.

Birthweight of Pigs.

Wisconsin Sta. Bull., 405 (1929), 51-3, 54, 63, 64.

A. H. Kuhlman and L. J. Cole have found that up to a birth weight of 2.8 lbs. the percentage of pigs raised increases, but heavier birth weights had no advantage. Only 75 per cent. of the pigs farrowed survived the first four days, and 37 per cent. were lost during a fifty-six-day suckling period. The average birth weight of 972 pigs farrowed by yearling sows was 2.35 lb. and of 1,344 pigs farrowed by aged sows 2.55 lb. At the end of the suckling period 207 pigs from yearling sows averaged 23.02 lb. and 227 pigs from aged sows averaged 27.1 lb., and the difference in weight at ninety-eight days of age was 9.38 lb. in favour of the pigs from aged sows. The results of this study indicate that pigs of a low birth weight are apt to be an economic loss, and that in general aged sows produce larger and more uniform litters and take better care of their pigs than yearling sows. A.D.B.S.

Butter Fat in Cow's Milk; Influence of Environmental Temperature on the percentage of.

H. J. Brooks, 1931. *J. Dairy Sci.*, V. XIV, No. 6, 483-93.

This paper reviews the subject of environmental temperature as it affects the percentage of fat in the milk. It also reports a careful investigation carried out by the author, of 409 cows representing four breeds of cattle, Holstein, Ayrshire, Jersey and Guernsey. In order to counteract the variable causes according to the month of calving, the author managed to arrange for an equal number of cows of each breed to calve each month, the figure being approximately nine for each breed per month. The results show clearly that environmental temperature exerts a greater influence upon the percentage of butter fat of cows milk than does the stage of the lactation. The lower the temperature the higher the percentage of butter fat, whilst the higher the temperature the lower the percentage of butter fat. That the change in the percentage of butter fat is not due to an alteration in the total yield of milk is shown by the figures. For instance, as regards the four seasons, the highest yield of milk per day, namely 26.2 lbs., was accompanied by 1.06 lbs. of butter fat, making 4 per cent. with the temperature at 54° Fahrenheit. In summer the average yield of milk per day was 24.7 lbs., with an average yield of fat of .96 lbs., making 3.8 per cent. at a temperature of 76°F., while for winter the average yield of milk per day was 28.7, the average yield of fat was 1.0, giving a percentage of 4.2 at an average temperature of 8.5. A.D.B.S.

Calf Crop Percentage on the Range.

C. W. Corbin. 1931, *The Cattleman*, V. 17, 11-29.

The writer discusses the many factors which have an effect upon the percentage calf crop on the range districts of the American States. From his figures it would appear as though the average calf crop ranges

between 60 and 65 per cent., but that where there were small pastures and a small head of stock the calf crop was higher than where the system of management was more extensive. Thus where the ranges number fifty breeding cows, the calf crop percentage was found to be around seventy, whereas where it was over 450 cows the percentage dropped to fifty.

The Hereford Springs Ranch at Tishomingo, Oklahoma, is quoted as obtaining one hundred per cent. calf crop, in fact one year it obtained one hundred and two per cent. The herd consists of 500 cows and is divided up into five bunches of 100 head. Each of these bunches is pastured and kept in separate pastures practically the entire year. Four bulls are used in each pasture during the breeding season. The last calf crop obtained under this system of management was ninety-two per cent.

Under range conditions, the ideal number of cows per bull appears to be from twenty to twenty-five. A.D.B.S.

Calving Interval and Average Milk Yield; Length of.

W. L. GAINES and J. R. PALFREY. 1931, *J. Dairy Sci.*, V. 14, No. 4, 294-306.

In this paper the term "calving interval" refers to the period from one calving to the next. In practice this is usually rather over a year. The present paper deals with the effect of the length of calving interval on the average milk yield. The records upon which this study is based are those of Langmack, and are confined to 186 Red Danish cows whose records in each case start with the cow's first calf and continue uninterruptedly throughout the nine following calvings. The yield is considered on an energy basis in terms of 4 per cent. milk, as already described by Gaines. The authors find a negative correlation between calving interval and yield over the current calving interval and a positive correlation between calving interval and yield over the following interval. The authors state that if it is desirable to shift the time of year of calving it appears that the calving interval might be prolonged to eighteen months without adversely affecting the average yield per day, considered over both the current and following intervals.

A.D.B.S.

Colour Inheritance in Sheep. VI, The Genetic Constitution of the Wild Mouflon.

J. A. FRASER ROBERTS. (Wool Industries Res. Assoc., Leeds). *J. Gene.*, V. XXV, No. 1, November, 1931.

Crosses between Wild Mouflon sheep and Black Welsh Mountain sheep have been observed. A small second generation (F2) was raised by mating a crossbred ram with crossbred ewes and the crossbred ram was also mated with brown Shetland ewes. The results make it possible to say that the Wild Mouflon does not possess the following nine factors:—Dominant black; Dominant brown; white; Badger-face pattern; the two that give coloured or spotted faces and legs in a white-fleeced sheep; black-headed pattern; the one for white collar in a coloured sheep; that which results in lambs being born grey instead of black.

Genetically the Mouflon is a recessive black and possesses the reversed badger-face pattern factor.

The paper also includes notes on the coat colours found in other wild sheep besides the Mouflon, viz., The Urial Group, The Argali Group, The Bighorn Group, The Barbary sheep, the Bharal sheep.

The undercoat of all these types is either brown or white; in no case is it black. All the members of the Mouflon and Urial groups, the Bharal and certain members of the Argali and Bighorn groups show reversed badger-faced pattern. The Barbary sheep is self coloured.

R.G.W.

Growth and the Development of Mutton qualities in Sheep.—A Survey of the problems involved in Meat Production.

By JOHN HAMMOND with a section in conjunction with A. B. APPLETON. pp. XXVI + 597. (Edinburgh: Oliver & Boyd). Price 42/-.

In their general introduction the writers describe their work as an attempt to approach the problem of meat production by observations on the product—meat—itself. Thence, by working backwards, to find out the conditions or factors which affect its formation. "Hitherto the science of animal nutrition has approached the subject from the feeding side and has stopped short at the digestion of the food stuff and the total body weight of the animal". The opinion may be hazarded that breeders, even more than feeders of stock, will find in this book a flood of light thrown on their problems.

Mr. Hammond's work on various aspects of the Physiology of Farm Animals is well known, and in a number of papers he has revealed glimpses of his researches on sheep, but few can have been prepared for the appearance of a book of nearly 600 pages on "Growth in the Sheep". To those who know Mr. Hammond it is superfluous to add that, bulky though the volume be, it is all "solid meat".

The book is divided into five parts, each of which has its special interest for the thoughtful flockmaster. Part 1 deals with the "Rate of Growth in Live Weight" and shows the variations due to seasonal differences, sex, age, time of lambing, feeding, &c. The experimental material was provided by the pedigree Suffolk flock formerly maintained at the Cambridge University Farm, but in the discussion of the results a world-wide range of investigation is drawn upon. Unfortunately, the results with Welsh lambs obtained at Aberystwyth by Phillips, and published in Vol. IV of this Journal, appear to have been overlooked, though the Bangor sheep crossing trials are referred to on more than one occasion. Consideration of space do not permit even an enumeration of the points brought out in this section. It must suffice to say that their importance will be appreciated at once by the keen breeder.

Part 2 on "Carcase Percentage and the Relative Development of the Different Organs in the Body," and Part 3 "Variations in the Rate of Development of Different Parts of the Skeleton" appear at first glance to be of more physiological and academic interest. A careful reading, however, reveals not only their great fundamental importance, but also their bearing on problems of immediate interest. In the experimental work several breeds, including Welsh, were used and the inclusion of wild or semi-wild types (Soay and Shetland) brings out clearly the changes in conformation and carcase qualities effected by the improvers of our domesticated breeds. These parts include a detailed investigation of the factors which determine such economic characters as conformation and early maturity and the influence on

them of nutrition, sex, breed, &c. Apart from the comparison of Welsh with other breeds, many questions of special interest to breeders of mountain sheep are fully dealt with, *e.g.*, the effect of environment not only on rate of growth and size, but also on conformation; the need for providing the best possible conditions in order to have genetic variability fully revealed; the greater variability in rams than in ewes owing to the inhibition of growth in the female which limits the full expression of latent capabilities; the effect of a heavy head and horns in producing a high, sharp shoulder.

Part 4 deals with "Variations in the Proportions of Muscle, Fat and Bone in the Carcase"; questions of interest not only to the breeder and feeder, but also the butcher and housewife. Again, a number of breeds, including semi-wild types, were utilised and the results of careful dissection of the various parts clearly tabulated and discussed.

Part 5, written jointly by Mr. Hammond and Dr. A. B. Appleton, is a detailed Study of the Leg of Mutton, designed to secure exact knowledge of the factors determining the economic value of meat. The investigation covered such points as structural and chemical differences affecting the toughness and flavour of different muscles, the distribution of fat, the difference between breeds, the relationship between bone weight and muscle weight, &c.

The book, though necessarily highly technical in parts, is written in a clear and straightforward style. The matter is well illustrated by photographs and diagrams excellently reproduced, and, though the book is hardly likely to appeal to the average breeder, it should be well within the comprehension of those who have had a college course. Such would find in it a store of interest and stimulus. One envies the County Organiser or Lecturer who has the opportunity of studying it section by section with a class composed of keen mountain farmers and shepherds.

The publication of the book appears to have been only made possible by a guarantee from the Empire Marketing Board. While grateful acknowledgement of their great service must be paid to the Board, it is to be hoped that grounds for the implied reproach to British stock-breeders will soon disappear and that some proportion of the vast sums lavished on preparations for our showyards may be diverted to work such as this. It may not have the same sporting attraction, but it represents far more solid achievement, and, above all, it has permanent value.

The Editors are to be congratulated on having included this work in their series of Biological Monographs. R.G.W.

Inbreeding Experiment with Poland China Swine.

McPHEE, RUSSEL and ZELLER. *J. Hered.*, V. 22, No. 12, 1931.

The experiment was started in 1922, when six gilts and their litter brothers were selected to start inbred lines. Three more gilts were added to the foundation stock in the following year.

The type of mating employed was brother with sister, and as far as possible litter mates were selected. The results were compared with those from similar non-inbred stock kept under the same conditions. The experiment was terminated after the second generation of close inbreeding, apparently mainly because of difficulty in keeping up the numbers of the breeding stock.

In the first generation the numbers in the litters were not significantly less than those of non-inbred pigs, but the average weight at birth and the percentage of pigs reared to ten weeks were less than in the control stocks.

In the second generation the numbers in the litters became very much reduced and the vigour of the pigs greatly decreased.

Very few second generation pigs could be reared to ten weeks.

There was a slightly higher proportion of still-born pigs among the inbred than among the controls.

The percentage of males in the litters was greater among the inbred than among the controlled. Among the non-inbred pigs on the same farm there were 52.85 per cent. of males; of the 189 first generation pigs in the inbred experiment, 58.73 per cent. were males; of the sixty-four second generation inbreds, nearly 61 per cent. were males.

It is suggested that the explanation is a greater rate of mortality before birth in the case of the females.

In the course of the experiment several undesirable characters appeared, presumably because of segregation of recessive factors. These included peculiar colour, cleft palate, scrotal hernia, and the ridgeling character.

It is pointed out that the results are not necessarily typical of the breed; other strains might show very different results with the same amount of inbreeding. R.G.W.

Inheritance of "Hairlessness" in Swine.

ELMER ROBERTS and W. E. CARROLL, University of Illinois. *J. Hered.*, V. 22, No. 4, 125, April, 1931.

Pigs which are practically hairless have been known for some time in parts of Mexico. This condition is distinct from the hairlessness caused by a deficiency of iodine. The breeding experiments reported in this paper indicate that the difference between "normal" and "hairless" conditions is due to a single factor. The normal condition is only partially dominant. R.G.W.

Linkage Studies in Sheep.

BORIS WASSIN. The Central Station for Animal Genetics, U.S.S.R. *J. Hered.*, V. 22, No. 1, 9, January, 1931.

A technical paper discussing data which throw light on the linkage relationships between white coat colour, additional teats and wattles. R.G.W.

Methods of Breeding the best Shorthorns in the United States during the period 1920-1928; Study of the.

E. E. BROCKLEBANK and L. M. WINTERS. *J. Hered.*, V. 22, No. 8, 244, August, 1931.

The writers have examined the breeding of prize-winning animals at shows from 1920 to 1928 in order to study the extent to which inbreeding has been followed successfully. They point out that genetic studies would lead one to expect that great sires and great dams would be produced by inbreeding and that outcrossing would give the best show animals. Actually, they found that successful breeders had not practised inbreeding to any appreciable extent, neither was there evidence of outcrossing in the production of prize winners. R.G.W.

Milk Production in Dairy Cows; New View of the effect of temperature on.

K. W. D. CAMPBELL. 1931, *J. Agr. Sci.*, V. 21, Part I, 167-77.

As a result of the investigation dealt with in this report, it would appear to be evident that the one environmental factor during the summer of 1928 that was least constant was temperature, and the author suggests that it is this lack of constancy in temperature and the wide variation between day and night temperature which was primarily responsible for fluctuating milk yields and fluctuating and low fat percentages.

The wider the temperature range the greater the depression of milk yield. The author also suggests that an appreciable variation of the minimum fat percentage is noticeable during periods of wide temperature range. The author is of opinion that the temperature variation over twenty-four hours is a fruitful cause of morning milk being low in fat under twice daily milking conditions with uneven intervals.

A.D.B.S.

Naked Lamb.

E. T. POPOVA-WASSINA. Dept. of Genetics, Zootechnical Inst., Moscow, U.S.S.R. *J. Hered.*, V. 22, No. 3, March, 1931.

Describes the occurrence of a lamb which had no covering at birth and did not develop wool or hair afterwards. In all other respects it was normal. The parents were normal black, short-tailed Russian sheep, with white patches on the head and the tip of the tail. They were closely related. The abnormal animal—a ram—is being retained for breeding experiments.

R.G.W.

Number of daughters necessary to prove a Sire.

JAY L. LUSH. 1931, *J. Dairy Sci.*, V. 14, No. 3, 209-20.

During the past few years increasing emphasis has been laid upon the progeny test of sires as a means for the improvement of farm livestock. The use of the progeny test is nothing new. Bakewell of Dishley used it to the fullest advantage. With the exception of a few of the leading breeders the proper value of it does not appear to have been appreciated, at least until recent years. It is due to the arrival of the Science of Genetics that attention has been drawn to this point. Only in the last ten years have adequate methods been available for combining genetics and statistical procedure to study the usefulness of the progeny test under varying conditions.

In the paper under review, Professor Lush sets out to investigate the number of daughters necessary to prove a dairy sire, and the material which he takes comes from a list of bulls which had fifteen or more daughters entered in the Register of Merit of the American Jersey Cattle Club. In his argument, Professor Lush leads the writer into the realms of higher mathematics and the " path coefficient " method of analysing correlation coefficients into their component parts as laid down by Dr. Sewall Wright.

Professor Lush draws attention to the difficulties that beset the proper appreciation of the progeny test which may be due entirely to environmental and nutritional causes and which must be taken into account. He also states that where close inbreeding is adopted, the argument must be modified. The more carefully environmental conditions are controlled and made uniform for all the daughters which are

to be tested the better the correction factors which may be used and the more accurate are the results which are likely to be obtained.

Firstly, on the point as to whether it is sufficient to take the daughters' records without taking into account the records of the dams of those daughters, Professor Lush states that the increase in accuracy by taking into account the yields of the dams is really comparatively small. The use of daughter-dam comparisons in the proper evaluation of the progeny test should make such a test more reliable, but the effect of so doing is less than is generally believed.

Comparing pedigree, performance and progeny test, if the records of three daughters are available this is of as much value as the records of every animal in the pedigree back to three or four generations. In general, the writer states that when there are as many as four to six offspring included in the progeny test this will be about as accurate as an estimate based on even a more complete pedigree. However, there are sure to arise occasions when sires with good hereditary constitutions are used in herds where their daughters are under conditions of bad husbandry. Under such circumstances the progeny test by itself may not be so reliable a basis for estimating the value of the bull as his pedigree would have been. Professor Lush states most strongly that he cannot see any logical reason for excluding pedigree or the individuality of the bull even if an infiite number of progeny tests were available.

With regard to the number of daughters which must be tested before an adequate proof may be made of the sire, the writer comes to the conclusion that the number five, the figure adopted by the U.S. Bureau of Dairy Industry, is as practical as any other. Certainly it is more accurate than the progeny test based on three or four, while on the other hand the increase in accuracy which would be gained by requiring more than five tested daughters would be large only when there was a big difference as regards environmental conditions.

There are already "on the market" various methods of working out the progeny test. Some of them are based simply on the records of the daughters, others upon the records of the daughters in relation to those of their dams. The one which so far appears to have made headway amongst breeders in this country is the Mount Hope Index which is based upon the difference between the yields of the daughters and the dams, that difference being used so that the bull gets credit for increasing the yield of his daughters and on the other hand gets penalized if he decreases it. This Index has been adopted for Guernsey cattle on that island and by one Milk Recording Society in England. A proper appreciation of this test by the dairy cattle breed societies and the publication by them of the performances of the progeny of bulls should undoubtedly effect an improvement in the quality of the dairy cattle of this country.

Incidentally, this writer shows that as regards pig testing stations, three litter groups of four pigs, each from one boar should give an exceedingly good index of the value of that boar.

Dr. Lush concluded by stating that the progeny test is rightly esteemed as one of the most valuable weapons which the breeder has at his command, but he warns his readers to save themselves from disappointment by keeping in mind the principles on which the reliability of the test is based and thus know how much confidence should be placed in it.

A.D.B.S.

Oestrual Cycle in the Sheep; Observations on the

FRED F. MCKENZIE and RALPH W. PHILLIPS, 1930, 23rd *An. Meet. Amer. Soc. Ann. Prod.*

These observations were made at the Missouri Agricultural Experiment Station during the breeding seasons of 1929 and 1930. Pure bred Shropshire, Southdowns and Hampshires were used. There were 97 ewes and in addition 25 ewe lambs. The breeding season began about the last day of August, the Hampshires, as a rule, coming into oestrum about ten days ahead of the other two breeds.

The duration of oestrum varies with individuals, the average being, in this case, 26.8 hours. Only 3 per cent. of all oestrual periods were less than nine hours or more than forty-eight hours. The shortest period observed was five hours and the longest fifty hours. In the lambs the average was 19½ hours and the extremes eight and forty-one hours.

As regards the different breeds the duration of oestrum for the Hampshire, Shropshire and Southdown was respectively 30.7, 26.8 and 24.0 hours, a longer period for the Hampshire being mathematically significant as compared with the other two breeds. The length of the interval from the first of one oestrum until the first of the next oestrum varied with the individuals but the intervals were remarkably constant in ninety-two of the 116 periods observed. It ranged from 14—16 days in length.

As regards the best time in which to mate, all the ewes were mated at one of three stages in oestrum, during the first six hours, from six to fourteen hours or after fourteen hours from the beginning of oestrum. When mated to rams of only fair fertility 70 per cent. of ewes bred after the fourteenth hour of oestrum while only 85 per cent. of the ewes bred before that hour conceived. When a highly fertile ram was used these percentages rose to one hundred and sixty-six respectively. Hence the writers conclude that it is important to breed in the latter part of oestrum. A day starvation period during the early part of the breeding season had no noticeable effect on the onset of the first oestrum of the season. A.D.B.S.

Periods of Embryonic Growth in Cattle.

DR. A. KISLOVSKY and B. A. LARCHIN (Department of Animal Breeding Institute of Dairy Farming, Molochnaia, near Vologda, U.S.S.R.). *J. Agr. Sci.*, V. XXI, Part 4, 659.

The writers advance the view that the growth of the embryo is not one of regular development but that there are definite breaks in the growth curve. Between these breaks growth is made at a steady level with minor fluctuations. The authors claim to have demonstrated the occurrence of five such periods of growth after forty days from conception. The breaks occur at different times and the growth periods are of different lengths in different breeds. In some, as in the well-developed dairy breeds, the last break in the rate of growth is passed in the foetus before birth so that the progress of the calf is uninterrupted. In other breeds there may be one or two breaks after birth. The possibility seems one to be kept in mind by those carrying out calf-rearing trials, particularly when comparing two or more breeds.

R.G.W.

Progeny Performance Test of Boars of Danish Landrace Breed.

By J. JESPERSEN and M. P. ØSTERLUND MADSEN. *Bull. Royal Vet. and Agri. Coll, Copenhagen*, 1929.

Three principal characters are considered in this report which is very full and includes large numbers of figures and graphs. These are body length, thickness of belly and thickness of back fat. The study covers seventy-seven boars each having from five to twenty litter groups which have passed through the testing station. Each litter group consisted of four pigs, but it does not always consist of two males and two females and in some of the litter groups owing to the death of one pig the records are not complete. It must be considered also that there is a possibility that the best animals are not always submitted to test but are retained for showing and breeding. Also there is seldom more than one litter tested from each sow particularly if the first litter is above par and therefore the maternal influence on the record of the progeny of any particular boar can only be estimated. The writers find a positive correlation of 0.2 between thickness of belly and thickness of back fat while there is a negative correlation between length and thickness of back. The long animal has a thin back and a fine shoulder and therefore length is a useful point for which to select. The writers state that this character is not greatly affected by nutrition or environment.

There then follows an interesting pedigree analysis of famous animals which have made the Danish Landrace breed what it now is and a rough outline of the inheritance of economic characters is traced.

Altogether this is an interesting paper though it can hardly be classed as of scientific value. Until some method can be obtained for taking into account the sows to which prominent boars are mated, it is difficult to state which boars have been or are of the greatest value to the breed. One has a feeling that the best use has not been made of all the material which is available and which is based on 8,000 animals a year for seven years. A.D.B.S.

Range Sheep Industry.

L. E. KINDT. *The Economic Analyst*, V. VII, No. 1, Jan., 1932.

The majority of the sheep ranches in Western Canada have been surveyed and the results classified according to the size of the breeding flocks. The total stock on the 130 ranches examined consisted of 135,000 ewes, 98,000 lambs, 8,000 wethers over one year and 3,000 rams. The average weight of all the lambs at the date of sale was 61.6 lb. and the lamb crop was 71.7 per cent. The crop of lambs and the average weight of lambs when sold decreased as the size of flock increased. In flocks of less than 500 ewes the percentage of lambs was 84.2 and the weight at sale 71.6 lb. In flocks of 2,000 or more ewes the corresponding figures were 68.1 per cent. and 57.2 lb.

R.G.W.

Secondary Sex Ratio in a Group of Dairy Shorthorn and Welsh Black Cattle; Observations on the.

E. J. ROBERTS (University College of North Wales, Bangor). *J. Agr. Sci.*, V. XX, 859.

The writer examined calving records of eighteen dairy herds, of which five were Dairy Shorthorns, the remainder Welsh Black Cattle. Taking the totals from all the herds, bull calves numbered 2,447 and

heifer calves 2,465, giving a secondary sex ratio of 99.8. In the case of the Shorthorns, the ratio was 97.1; in the Welsh the proportion of bull calves was slightly higher, the ratio being 100.9. This difference between the two breeds is not significant in view of the great fluctuations from herd to herd, but it is noted that on one farm where the two breeds had been kept under similar conditions for seventeen years the proportion of bull calves had been consistently higher in the Welsh breed.

Effect of Season.—The results of this investigation confirms those of other researches and show that the proportion of bull calves born is distinctly higher in both breeds during the winter months September—February than in the summer period March—August. The latter period is the period of highest birth rate and it includes conceptions during the spring flush of grass. R.G.W.

Sheep Classes in the Carcase Competition of the Smithfield Club, 1895-1929.

E. J. Roberts. *J.R.A.S.E.*, V. 91, 1930.

The Smithfield Carcase Classes probably provide the most useful exhibit which the sheep breeder can find at any show throughout the year, and there is no better way of advertising a breed able to produce high quality carcases. This account of the competition from its beginning in 1895 to 1929 has a special interest for Welsh readers in that it includes an unbroken run of six years (1924-9) success for Welsh Mountain lambs in the class for Longwoolled and Mountain breeds. It is only fair to add that many more such successes have yet to be secured before the number will equal those of the Blackfaces, whose breeders have since 1916 entered large numbers of sheep for the competition. In the Shortwoolled classes Southdowns have in recent years been the most numerously represented breed and have taken most of the prizes. In the earlier years of the competition Suffolks were more prominent.

The tables show a steady decline in the weight of prize-winning animals amounting in the Longwools to 21 per cent. and to 30 per cent. in the Shortwools. This applies equally to the lambs and the older sheep. The percentage of carcase also showed a steady decline to 1913, but since 1919 there has been a recovery. During the last ten years the yearling sheep on an average gave 3.3 per cent. more carcase than the lambs, the carcase of the former ranging from 58.6 in the Blackfaces to 60.6 per cent. in the Suffolk; Welsh 57.1 per cent. The lambs varied from 50.9 per cent. carcase in the Blackface to 56.9 in the Suffolk; Welsh 53.2.

Incidentally the competition illustrates the difficulty which even experienced judges have in estimating carcase quality. In the earlier years the animals were judged before slaughter though, as now, the final placing depended entirely on the judging of the carcases. Out of eighty-eight animals placed first when alive, only eighteen gave first prize carcases. Again, in thirteen out of the seventeen years the champion carcase was produced by an animal not placed first even in its own class. On all occasions the judges were butchers of long experience and high standing. R.G.W.

Swine Inbreeding at the United States Department of Agriculture Laboratories and at the State Experiment Stations.

HUGH C. MCPHEE, 1930, 23rd *An. Meet. Amer. Soc. An. Prod*, 128-31.

The writer reports experiments on the inbreeding of pigs which have been conducted at four centres in the United States. At all four places the results indicate a loss in vigour as a result of inbreeding and no correlation was found between birthweight and degree of inbreeding. But between weaning weight and degree of inbreeding there was found to be a very close association. It is reported that inbred and outbred pigs weighed practically the same at sixty days of age and that the difference in time exhibited to reach 225lb. live weight was about 8 per cent. in favour of the outbred pigs. From the University of Minnesota it was found that there was a reduction in vigour after the inbred pigs had reached 100lb. live weight. At Beltsville the period of slow growth in inbred pigs began much earlier than this when it began to be pronounced soon after weaning.

Two investigators reported the trouble found in inbreeding work of inability to get certain inbred boars to mate with their full sisters. It is reported that structural abnormalities which have appeared amongst the inbred pigs have been rather rare at Minnesota only one cryptorchid was produced though a number of unusual sex types occurred. At Beltsville the only defect met with was a cleft palate and this line died out. A.D.B.S.

Testing and Mating Mares; Best Method of.

SCHTSCHTEKIN, V., 1930, *Ztschr. Zucht.*, 18, 447-54.

The Russians in their large scale horse-breeding establishments have a unique chance to study many points concerning the fertility amongst horses and they do not appear to be slow to take that opportunity.

This paper embodies the results of three years' observations of the Khrenovoye Stud upon over one hundred Orlov mares and sixty Percheron mares. The practical conclusions which may be drawn from this extremely interesting paper may be summarised as follows:

Mating on the second day of oestrus has a marked difference as compared with that of the first day. This compares with the work of other authors. The mares should be mated at every oestrus cycle during the breeding season. This greatly increases the chances of fertility. Mating on the first day with a repetition on the fifth day gives better results than the first day of " heat " but these results are no better than when a single mating takes place on the second day. Beyond a few exceptional cases it is sufficient if a mare be mated on the second day of oestrus. This does not agree with Aithen (1927).

A.D.B.S.

Uber einige das Geschlechtsverhaltnis beeinflussende Faktoren. (Some factors effecting the sex-ratio).

H. KRALLINGER. 1930, *Zuchtungskunde*, V. 5, 480-502.

From data numbering over 47,000 animals of two German breeds, the sex ratio was found to be 50.57 ± .23. From 35,000 animals no seasonal variation in the sex ratio could be observed. Nevertheless there does appear to exist a factor responsible for the production of a definite sex ratio and this may be present in either sex. Small litters with ten or under have a slightly higher number of males than large

litters and it is probable that the sex ratio is slightly higher in first births but this was not conclusive.

To these facts is appended an interesting discussion on sex ratio and sex determination generally. Apparently a rise in the sex ratio (more males) is associated with a lower fertility and probably owing to difficulty of fertilisation. Attention is drawn to an attempt made in Germany to cure sterility by a special treatment. This treatment produces an astonishingly high proportion of males. The possibility is discussed of the application of similar methods for domestic livestock but since it would appear impossible to obtain a higher sex ratio without impaired fertility there lies a danger in this method.

A.D.B.S.

Yield and Quality of Milk; Factors affecting the. II, Variations in Successive Lactations.

J. GLEN and ANDREW C. M'CANDLISH (West of Scotland Agr. College, Glasgow). *J. Agr. Sci.*, V. XX, p. 45.

This paper continues the account abstracted in Vol. VI, p. 351, and is based on the examination of a large number of Ayrshire records. The writers conclude that—

1. Milk and butter fat production rise to about the sixth lactation, but beyond the fifth lactation the increase is negligible.

2. The lactation of maximum production may be taken as the fifth which corresponds to seven years of age.

3. Beyond the fifth lactation the milk and butterfat yields vary irregularly but show a downward tendency.

4. The fat yield shows either a fall or only a very small increase in the second lactation.

5. The fat percentage is highest in the first lactation, drops markedly in the second, remains fairly steady for a few lactations, though with a slight downward tendency, and then falls off in the higher lactations.

6. Results obtained by applying correction factors for either age or lactation are quite comparable and choice in the method to be used will depend largely on the original data available.

R.G.W.

Zebu-Yak Hybrids; Sterility of Bulls, Fertility of Cows, and Material on the Genetics of Zebu-Yak Hybrids.

M. M. ZAWADOWSKY, Moscow Laboratory of Experimental Biology. *J. Hered.*, V. 22, No. 10, 297, October, 1931.

Crosses between a Zebu bull and Yak cows have been made in the Zoological Park at Moscow. The female hybrids are fully fertile and the females produced by backcrossing them with their Zebu sire are also fertile, but the hybrid bulls and the bulls produced by the back-cross are all sterile. Post mortem examination showed that this is due to a complete absence of developed generative cells. The hybrids and the back-crosses provided information regarding the inheritance of certain characters, including " Fringe ", Horns, Shape of Muzzle, Shape of Hump, length of Tail Hair.

Coat Colour.—The black-brown colour of the Yak is dominant while the grey colour of the Zebu is recessive.

Length of Hair.—The short hair of the Zebu is incompletely dominant over the long-haired Yak type.

Body proportions.—The long, bony form of the Yak is dominant over the big square form of the Zebu. In the second generation some signs of segregation were observed, but it was evident that body proportions are affected by many genes and inheritance is therefore very complicated. R.G.W.

SOILS AND MANURES.

Abstractor: RICE WILLIAMS, M.Sc., University College, Bangor.

Ammonium-Calcium Balance; A Concentrated Fertiliser Problem.

L. G. WILLIS and J. R. PILAND. *Soil Sci.*, 1931, 31, 1, 5-28.

In pot experiments with a sandy soil of low absorptive capacity, a mixture of diammonium phosphate, potassium nitrate, and potassium chloride was toxic to cotton seedlings. The cause of the injury was related to some property of the diammonium phosphate. Injury by ammonium sulphate, chloride, or nitrate was not observed. The free ammonia formed by the hydrolysis of diammonium phosphate was apparently considered to be the most toxic component. Calcium salts were antagonistic to ammonia toxicity, the sulphate and chloride being more effective than the carbonate. The conversion of free ammonia to carbonate in the soil and its partial neutralisation by reaction with the calcium salts could account for the greater part of the beneficial effect of the calcium salts, but there was some evidence that physiological antagonism was also a factor. Monoammonium phosphate alone produced a lesser degree of injury than did diammonium phosphate. This relation was reversed when both were mixed with calcium sulphate. R.W.

Artificial Manure; The Production of.

Iowa Sta. Rep., 1929.

Various chemicals were mixed by means of an attachment used with the thresher and about 400 gallons of water per ton of straw added to supplement the rainfall, which was inadequate for satisfactory decomposition. A good quality product was obtained in this way. Greenhouse tests on the effect of aeration on decomposition showed that reworking was not necessary if the straw was uniformly and sufficiently wetted. Adco and mixtures of cyanamide were the most efficient reagents for stimulating decomposition. Indications were obtained that inoculating the straw with fresh horse manure or with soil would hasten decomposition very considerably. R.W.

Farm Manure; Conservation and Availability of the Nitrogen in.

A. F. HECK. *Soil Sci.*, 1931, 31, 5, 335-68.

Laboratory and greenhouse studies on the changes, losses and availability of the nitrogen in farm manure carried out at the University of Wisconsin, are reported. Some of the results are the following: (1) Under anaerobic conditions the urea and other water-soluble nitrogen compounds are ammonified and an acid fermentation takes place with the formation of volatile organic acids which react with the ammonia forming salts. (2) When liquid manure was stored alone, a loss of ammonium carbonate from solution by volatilisation was observed. This loss could be reduced almost to nothing by covering the surface of the liquid with a thin layer of mineral oil. (3) If there is no loss of nitrogen from cattle manure, 50 per cent. of the

total, or 100 per cent. of the liquid, manure nitrogen should be recovered in the first crop under normal conditions. R.W.

Fertiliser Investigations of the Wisconsin Station, Wisconsin.
Wisconsin Sta. Bull., 1931, 420, 42, 43.

The important fertiliser requirement for drained peat marshlands was found to be potash. 200-300 lb. of muriate of potash produced satisfactory yields. This was generally supplemented with some superphosphate which, however, was detrimental to some crops, *e.g.*, tending to increase the lodging of grain crops. R.W.

Free-Ammonia Injury with Concentrated Fertilisers.
L. G. WILLIS and W. H. RANKIN. *J. Ind. Engin. Chem.*, 1930, 22, 12, 1405-7.

Cotton seed meal used as a fertiliser was found capable of causing serious root injury to seedling plants in light sandy North Carolina soils. This injury was found to be related to a high concentration of free ammonia in contact with the roots, and could be removed by the addition of gypsum or by allowing the fertiliser to remain in the soil until the ammonia had been dissipated by diffusion or volatilisation. Nitrification in the presence of free ammonia seemed not to be effective as a preventive to injury. In concentrated fertilisers of the nature of cotton seed meal containing ingredients decomposable into free ammonia, some calcium salt appeared to be necessary. R.W.

Green Manures; The Comparative Values of various Green Manures—in the formation of Soil Nitrates and Available Humus.
J. W. WHITE, *Pennsylvania Sta. Bull.*, 1930, Bull. 258, 15, 16.

Experiments were carried out with equal dry weights of green immature residues of various crops mixed with soil and kept in large jars in the dark for nine months. At the end of this period determinations of organic matter and humus were made. The nitrates were determined at intervals. Red clover was found to be the most effective leguminous green manure. Whilst among the non-leguminous residues, rape was most effective in supplying soluble nitrogen and wheat in supplying humus and organic matter. R.W.

Limestone in Soil; The Influence of Season upon the disintegration of.
W. H. MCINTYRE and W. M. SHAW. *J. Amer. Soc. Agron.*, 1930, 22, 3, 272-6.

Experiments were carried out at the Tennessee Experiment Station on the decomposition of ground limestone and dolomite by an acid soil. Disintegration took place chiefly during the periods when there were effective concentrations of CO_2 in the free soil water. The supplies of CO_2 available during the spring months and during the intermittent periods of the summer months were more effective than those supplied during the fall and winter months. During the latter period the rainfall was not so easily evaporated and the interstitial pore spaces were filled with water within temperature ranges which were not conducive to the generation of CO_2. Previous experiments on the same soil had shown that the addition of limestone or dolomite increased the accumulation of nitrates and sulphate during the period April to October, and that during the winter months the production of nitrates was practically nil. It is concluded that, under fallow conditions, the decomposition of

dolomite and limestone is most extensive during the season when temperatures and the periodicity of rainfall produce the greater biological activities. R.W.

Nitrogenous Fertilisers; The Leaching out of Autumnal Dressings.

H. H. NICHOLSON and B. PANTIN. *J. Agr. Sci.*, 1929, 19, 2, 297-301.

Experiments were carried out at Reading on the leaching out of nitrates following the application of autumnal dressings of cyanamide, rape dust, and sulphate of ammonia. The results bear out the conclusion of the Rothamsted experiments that leaching may occur any time throughout the winter up to March or, rarely, April. The loss of nitrate is directly limited by the amount of drainage and so is indirectly determined by rainfall, and by temperature. All three nitrogenous fertilisers are shown to lose well over 50 per cent. of a normal dressing by leaching out during the winter. Sulphate of ammonia shows the greatest loss and rape dust the least, calcium cyanamide being intermediate. R.W.

Photosensitized Oxidation of Ammonia and Ammonium Salts and the Problem of Nitrification in Soils.

G. C. RAO and N. R. DHAR. *Soil Sci.*, 1931, 31, 5, 379-84.

The oxidation of ammonium salts to nitrite was found to be effected by sunlight in the presence of certain photosensitizing substances, the velocity being greater in quartz than in glass vessels. The following substances in order of decreasing sensitiveness were studied: Titanium oxide, zinc oxide, sodium uranate, aluminium oxide, and silica. The velocity of oxidation is favoured by basic conditions. The authors suggest that nitrification in soils is in part, at least, photochemical in nature, taking place at the surface of various photocatalysts present in the soil under the influence of sunlight. They believe that the bacterial and photochemical processes take place side by side. R.W.

Potash Shale as a Source of Potassium for Growing Plants.

H. C. HEATH. *Bot. Gaz.*, 1930, 90, 2, 121-56.

On the basis of the green and dry weights of plants of twelve species, grown in quartz sand and in potassium-deficient soils, the author concluded that plants, growing in potassium-deficient soils, derive considerable benefit from untreated potash shale when used as fertiliser. Shale roasted at red heat for thirty minutes produced an even more marked response and contained a greater percentage of water-soluble potassium than the untreated mineral. A further increase in the amount of water-soluble potassium was obtained by roasting the shale with 37 per cent. of gypsum. Plants with more nearly neutral sap received about double the benefit from shale than that which was received by plants with more acid sap. Shale, roasted with limestone or gypsum, should prove a valuable fertiliser in applications of two tons or more per acre, especially on peaty soils and for certain crops like red clover. R.W.

Soil Acidity; The Quality of Clover and Timothy Hay as influenced by.

J. W. WHITE and F. J. HOLBEN. *Pennsylvania Sta. Bull.*, 1930, 258, 16.

Plots laid out in 1881 and cropped without liming showed exhaustion of the lime supply by the failure of clover crops, reduced yield of other crops, and invasion of the plots by sorrel and other acid-resistant plants. The results indicate that soils deficient in lime are unable even with liberal fertiliser treatment to produce hay of good quality. R.W.

AGRICULTURAL BOOKS, 1931.

The following list, prepared by the staff of the National Library of Wales, is a selection of the more important books on the science and practice of Agriculture published during the year 1931. The list supplements *The Hand List of Books on Agriculture* issued by the National Library, *third edition*, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

BEAUCHAMP, J. Agriculture in Soviet Russia. London : Gollancz, 1931. pp. 126 ... ... 2s. 6d.

BELSHAW, H. The Provision of credit, with special reference to agriculture. Cambridge : Heffer, 1931. pp. xviii, 326. *Auckland University College Texts, No. 1* ... ... 10s. 6d.

BEYLEA, H. C. Forest measurement. New York : Wiley, 1931. pp. xviii, 320. diags., bibl. ... $3.50

BLUNDELL, F. N. A New policy for agriculture. London : Philip Allan, 1931. pp. xii, 180. bibl. ... 7s. 6d.

CARNEGIE, V. M. A Kenyan farm diary. Edinburgh : Blackwood, 1930. pp. xii [ii], 272. front., pls. 7s. 6d.

CO-OPERATIVE UNION. *Publications Department.* Modern dairy management, by G. Walworth. Manchester : The Co-operative Union Ltd., 1931. pp. vi, [ii], 712. ill. ... ...

COUTTS, J. Everyday gardening. London : Ward, Lock, 1931. pp. 448. col. front., col. pls., ill., diags. 7s. 6d.
Ward, Lock & Co.'s All about gardening . . . *new rev. ed.* London : Ward, Lock, 1931. pp. 384. col. front., pls., ill., diags. ... ... 5s. 0d.

DAVIDSON, J. B. Agricultural machinery. New York, Wiley, 1931. pp. x. 396. ill., diags. *Wiley Agric. Engineering Ser.* $3.50

FABER, H. Co-operation in Danish agriculture, by H.F.; an English adaptation of *Andelsbevægelsen i Danmark* by H. Hertel. London : Longmans, 1931. pp. xxii, 188. front. (port.). ... ... 5s. 0d.

FAIRBRIDGE, D. Historic farms of South Africa. Oxford University Press, 1931. pp. xii, 194. col. front., pls. ... ... 32s. 6d.

GRAHAM, E. The Profitable small farm. London : Peter Davies, 1931. pp. 222. diags. ... ... 7s. 6d.

HILEY, W. E. Improvement of woodlands. London: Country Life, 1931. pp. viii, 250. front., ill. 10s. 6d.

HOWARD, A., *and* WAD, Y. D. The Waste products of agriculture: their utilization as humus. London: Humphrey Milford, 1931, pp. xiv, 168. ill., pls. 7s. 6d.

HUBERT, E. E. An Outline of forest pathology. New York: Wiley, 1931. pp. viii, 544. front., ill., diags., bibl. $6.00

HULTZ, F. S., *and* HILL, J. A. Range sheep and wool in the seventeen Western states. . . . New York: Wiley, 1931. pp. xviii, 374. front., ill., diags. ... $3.00

HUNTER, H. *Ed.* Baillière's Encyclopaedia of scientific agriculture. London: Baillière, Tindall & Cox., 1931. 2 vols., pls., diags. ... ... 63s. 0d.

JACOB, A., *and* COYLE, V. The Use of fertilisers in tropical and sub-tropical agriculture. London: Benn, 1931. pp. 272. ill. ... ... 10s. 6d.

JENSEN, O. S. O. Dairy bacteriology . . . transl. from the Danish by P. S. Arup . . . *2nd English ed.* London: Churchill, 1931. pp. x, 198. ill. ... 18s. 0d.

JUDKINS, H. F. The Principles of dairying . . . *2nd. ed. rev.* by R. W. Smith. New York: Wiley, 1931. pp. xviii, 322. front., ill., diags., bibl. ... $3.00

KEEN, B. A. The Physical properties of the soil. London: Longman's 1931. pp. vi [ii], 380. pl., diags. *Rothamsted Monographs on Agricultural Science.* ... ... 21s. 0d.

LEPPAN, H. D. Agricultural policy in South Africa. Johannesburg: Central News Agency, 1931. pp. 102 ... ... 6s. 0d.

McCONNELL, P. Note book of agricultural facts and figures for farmers and farm students . . . *11th ed.* London: Crosby Lockwood, 1930. pp. 540, xii. diags. ... ... 15s. 0d.

MANCHESTER: *University.* (*Agricultural Economics*). Grass and hay farming: an economic study by John Orr, Manchester University Press, 1931, pp. 38. pls., diags. ... ... 1s. 0d.

OXFORD. *University. Agricultural Economics Research Institute.* Factors affecting the prices of livestock in Great Britain: a preliminary study by K. A. H. Murray. Oxford: Clarendon Press, 1931. pp. viii, 180. diags. ... ... 6s. 0d.

The Farmer's business : comparative conditions in part of South Oxfordshire in 1928 and 1929, by R. N. Dixey, assisted by W. H. Jones and P. M. Reason. Oxford : Clarendon Press, 1931. pp. 28. map. ... ... 1s. 0d.

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